PHYTOTOXICOLOGY REPORT:

LAIDLAW ENVIRONMENTAL SERVICES

LIMITED, CORUNNA (1993/1994)

JANUARY 1996

Ontario

Ministry of
Environment
and Energy

ISBN 0-7778-4954-2

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Cette publication technique
n'est disponible qu'en anglais.

PIBS 2815E01

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Report prepared for:

Ontario Ministry of Environment and Energy

BACKGROUND and INTRODUCTION

Laidlaw Environmental Services, formerly known as Tricil Ltd., operates a hazardous waste landfill and incineration facility in Corunna, Ontario. The facility has generated much local concern and scientific attention.

The Phytotoxicology Section, Standards Development Branch, of the Ministry of the Environment and Energy (MOEE) has been involved in soil and vegetation assessments in the vicinity of the facility since 1977. During this time, the Section has conducted annual surveys and investigated a number of vegetation damage complaints from local property owners. To date, none of the vegetation complaints identified contaminants migrating off the site in soil, water or air.

Annual vegetation, soil and/or moss bag surveys have been conducted in the vicinity of the facility on 13 occasions since 1977. These surveys examined inorganic contaminants only. The number and location of sampling stations, the material sampled and the frequency of sampling has varied from year to year to expand or reduce the information base and to respond to changes in processes at the facility.

Annual surveys conducted up to 1984 found no evidence of vegetation contamination in the vicinity of Laidlaw. Slightly elevated concentrations of inorganic contaminants were found near the facility in 1985 through 1990. Specifically, in 1989 and 1990, aluminum, barium, calcium, cadmium and manganese were elevated in silver maple foliage collected around Tricil, but concentration gradients were not strong. A second group of elements had very low and consistent background levels with a marginal but distinct concentration gradient associated with the Tricil location. These included chromium, lead and mercury (mercury only in 1990). Even though these two groups of elements were elevated, none exceeded their corresponding rural ULN (Upper Limit of Normal) guideline. Moss bags also had elevated concentrations of calcium, chromium and magnesium in 1989 and 1990. There was no evidence, however, that soils collected around the facility in 1990 had been impacted by the facility[1]. Although a number of elements also demonstrated concentration gradients associated with Laidlaw in 1991 (i.e., aluminum, barium, cadmium, calcium, chromium, lead, manganese and zinc), none exceeded their corresponding ULN guideline. In addition, the zones of contamination tended to be smaller and less distinct in 1991 compared to 1989 and 1990[2]. The report summarizing the 1991 data concluded that the degree of contamination was environmentally inconsequential and would not interfere with the normal use of the land.

Analysis of tree foliage for inorganic parameters collected from a reduced number of sample sites in the vicinity of Laidlaw in 1992, re-affirmed the results of previous studies that emissions from the facility are not having a measurable adverse impact on the surrounding terrestrial environment. A limited survey of soils in the vicinity of the facility also found that concentrations of dioxins and furans were within background limits and not detectibly elevated near the facility.

This report summarizes the results of expanded field activities conducted in the vicinity of Laidlaw Environmental Services Limited, Corunna, in 1993 and 1994.

METHODOLOGY

Vegetation and soil collections in the vicinity of Laidlaw, in 1993 and 1994, were conducted in a similar manner to those in the past, with the following notable exceptions. Because of a series of possible changes to the land filling and incineration processes at the site and the resulting increased public concern, the number of stations sampled and the number of chemical parameters tested was increased relative to that conducted in 1992. The 1993 and 1994 surveys involved the collection of vegetation and/or soil from the 20 stations sampled in 1991 and earlier (see Figure 1). In the 1993 survey year vegetation and soil were collected from each station, while collections in 1994 were limited to vegetation only.

Foliar samples from silver maple trees were collected in duplicate from each of the 20 stations in September 1993 and in triplicate from the same stations in late August 1994. Samples were collected using pole pruners from the mid-crown of sample trees on the side of the crown facing Laidlaw. Samples were stored in plastic bags during transport to the Phytotoxicology processing lab. Samples were oven-dried, ground in a Wiley-mill and stored in glass bottles. Processed vegetation samples were submitted to the MOEE laboratory in Etobicoke for chemical analysis.

Surface soil (0-5 cm) samples for inorganic analysis were also collected from each of the 20 stations in 1993. Samples for organic analysis were collected from 7 stations (an increase from 4 in the 1992 study) that were selected to include locations close to and in the documented downwind gradient of the facility, as well as control locations. Samples for inorganic analysis were collected in duplicate while samples for organic analysis were collected in triplicate. All samples were collected from lawns rather than agricultural fields. Composite replicate samples were collected from a 100 m^2 area at each station. Each sample consisted of a minimum of 50 individual cores collected from random locations within the sample area using a stainless steel corer. Samples for inorganic analysis were stored in plastic bags during transport to the Phytotoxicology processing lab. These samples were air-dried, pulverized to pass through a 45 mesh sieve and stored in glass bottles. Soil samples for organic analysis were transported and stored refrigerated in amber glass bottles with foil-lined lids and submitted to the laboratory un-processed.

The number of inorganic parameters tested in 1993 and 1994 was increased to 21 for both vegetation and soil. Analyses were conducted for aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), cadmium (Cd), chloride (Cl), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), magnesium (Mg), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), sodium (Na), strontium (Sr), vanadium (V) and zinc (Zn). All analyses were conducted by the MOEE laboratory in Etobicoke. For the purposes of calculating means and for the purpose of mapping, values reported as below the detection limit were taken as a value of half the reported detection limit.

Replicate samples collected for organic analysis were analyzed for polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) by the Dioxin Unit of the MOEE Laboratory Services Branch. Each of the samples was also analyzed for polychlorinated biphenols (PCBs) by the MOEE laboratory in Etobicoke.

Inorganic elemental concentrations in vegetation and soil were compared to the MOEE Upper Limit of Normal (ULN) contaminant guidelines (where available) to assess the degree of contamination. The ULNs represent the maximum expected concentrations of selected elements in vegetation and soil in the absence of a point source of air pollution (Appendix I).

Dioxin and furan data were converted to Toxic Equivalents (TEQs) using the International Toxicity Equivalency Factors[3] and the isomer substitution formula derived by the MOEE Standards Development Branch (using individual replicate results rather than means)[4] and compared to the Canadian Council of Ministers of the Environment (CCME) interim guideline for TEQs in residential/parkland soil[5]. The analytical results for concentrations of PCBs were compared to the Canadian Council of Ministers of the Environment's "Interim Guidelines for PCBs in Soils"[6]. Further details concerning the above noted CCME guidelines are included in the results section.

Contour maps were produced from the vegetation and soil chemistry data using *Surfer Version 4* (options: Kriging with normal search method for as many points as possible, smoothing with a tension factor of 2, and grid size of 50 by 50). These maps are statistical approximations of the spatial distribution of the different contaminants. The contours produced by the program are significantly affected by the spatial distribution of the sampling sites, the accuracy of the positional information of the sampling sites, and the program options used to generate the contours. The accuracy of the contours falls off at the edges of the map and in large areas where there are no sampling sites. The maps should, therefore, only be used to provide information on approximate areas and/or patterns of contamination and cannot be used to infer concentrations of contaminants at locations not directly sampled.

Wind data normals (1967-1980) were obtained from the Sarnia A Environment Canada monitoring station, located approximately 8 km NE of the centre of Sarnia.

RESULTS and DISCUSSION

MAPLE FOLIAGE:

Annual wind direction and speed normals for the Sarnia A meterological station are illustrated graphically in Figure 2. The data indicate a strong tendency toward winds from the south (south and south southwest). Winds from the north and west are also common. The directionally-related wind speed pattern is generally symmetrical with a slight tendency for winds from the north to northwest being stronger and winds from the east being weaker.

The results of chemical analysis for the 21 inorganic elements in maple foliage for 1993 and 1994 are summarized in Tables 1 and 2, respectively. The results are reported in μg/g (commonly referred to as ppm or parts per million). Also listed in the tables are the Phytotoxicology Section ULN rural guidelines (where available). Levels exceeding the ULNs have been indicated in bold and underlined.

With the following notable exceptions, concentrations of inorganic elements in foliage, for

both sample years, were below the rural ULNs. As in earlier studies, the Cl concentrations in foliage exceeded the rural ULN at many of the sample sites in both 1993 and 1994. These elevated Cl concentrations could not be attributed to Laidlaw, but rather were almost certainly the result of natural salt deposits known to be common in Lambton county. However, unlike earlier years, the rural ULN for Hg was met or exceeded at stations close to the facility in both 1993 and 1994. Na also exceeded the rural ULN in foliage at two stations, one located in close proximity to Laidlaw, in 1993. The concentrations of Mn in foliage also exceeded the ULN at a single station in 1994 and at two sites in 1993. These exceedences of the ULNs, especially for mercury, in the vicinity of the facility are significant because they indicate that emissions from the Laidlaw facility have had a measurable impact on the terrestrial ecosystem.

The spatial gradients in elemental concentrations in foliage around the facility for all elements, including those exceeding the ULNs, can be inferred from concentration contour maps. Maps are provided only for elements for which there is sufficient range in the data. The data fell into three general categories: (1) elements for which the majority of data was well above the detection limit, (2) elements for which the majority of data was trace but above the detection limit and (3) elements for which the majority of the data was below the detection limit. While more certainty can be placed on information derived from data in the former category, earlier mapping of data around the facility in 1989 and 1990[1] has shown that useful information can be obtained from contours derived from predominantly trace concentration data sets as long as there is sufficient range in the data. The elements for which the majority of data was below the detection limit and for which there was not sufficient range in the data to produce contour maps were As, Co, Cr, Mo, Sb, Se and V. The contour maps for the rest of the inorganic elements in vegetation for the two sample years are included as Figures 3 to 30.

There were spatial gradients of elevated Al, Cd, Cu, Ba, Fe, Na and Hg in vegetation collected in 1993 and 1994 associated with the Laidlaw facility. The gradients for Hg and Na were particularly problematic because they were accompanied by exceedences of the ULN guidelines for foliage. As noted above, concentrations of Hg exceeded the ULNs at sites close to the facility in each of sample years (Site 24 in 1993 and Sites 6, 15 and 24 in 1994). The highest mercury concentration was 0.29 µg/g (almost 3 times the rural ULN) which was found at Site 15 (directly north of the landfill) in 1994. For both years the pattern of Hg contamination was distinctly oriented around Laidlaw in a north south-direction (consistent with the prevailing wind directions - Figures 3 and 4). The concentrations tended to be higher in 1994 than 1993 with the predicted area exceeding the ULN of 0.1 µg/g in foliage extending more than 2 km to the north and south in 1994. These findings were generally consistent with the results of spatial analysis of 1990 foliar data[1]. However, the concentrations in both sample years (1993/4) were higher than those found in 1989 through 1992[1,2] . The first exceedences of the ULNs for Hg in foliage in the vicinity of the Laidlaw facility occurred in 1993 and 1994.

Unlike earlier studies, elevated Na concentrations in maple foliage tended to occur at sites close to Laidlaw in 1993 and 1994 (Figures 5 and 6). The concentration contours were clustered more tightly around the facility in 1993 than 1994 indicating a comparatively stronger source-related pattern in 1993. The concentrations of Na were also particularly elevated at Site 15 in both sample years.

Concentration gradients associated with the Laidlaw location that were not accompanied

by exceedences of ULNs (where available) were found for Al (Figures 7 and 8), Ba (Figures 9 and 10), Cu (Figures 11 and 12), Cd (Figures 13 and 14) and Fe (Figures 15 and 16). While source-related concentration gradients for Al and Ba were also found in foliage collected in 1989 and 1990, the gradients for Cu, Cd and Fe were not found in the earlier studies.

Weaker and less diagnostic concentration gradients around the Laidlaw facility were found for Mn (Figure 17 and 18), Ni (Figure 19 and 20) and Pb (Figure 21 and 22). The gradients for Mn in foliage in 1993 and 1994 were similar to those found for the 1989 and 1990 data and consisted of marginally higher foliar Mn concentrations to the east and north northeast. although there was no source-related pattern for Ni in foliage in 1993 the pattern was evident, albeit weak in 1994. The reverse was true for Pb with a fairly stronger gradient and higher concentrations evident in 1993 in comparison to 1994. The range in the foliar Ni and Pb data was quite narrow which may have contributed to the confusing patterns for these elements.

As noted above, Cl concentrations in foliage that exceeded the ULN were thought to be attributed to natural salt deposits rather than activities at Laidlaw. This assertion is strengthened by the sporadic distribution of elevated salt pockets within the study area and the absence of a company-related distribution (Figures 23 and 24).

Similarly, there was no pattern of accumulation of the following inorganic elements in vegetation that could be associated with the Laidlaw facility: Mg (Figures 25 and 26), Sr (Figures 27 and 28), and Zn (Figures 29 and 30).

Even though the majority of foliar data was below the detection limit there were notable elevations at Site 15 (directly adjacent to the landfill to the north) for As in 1994 and for Cr in 1993 and 1994.

SOILS:

Inorganic Data

The results of chemical analysis for the 21 inorganic elements in surface soils (0-5 cm) for 1993 are summarized in Tables 3. As with foliage the results are reported in µg/g and are compared to the ULN guidelines for rural soils (where available). The OTR_{98} guideline for rural parkland is substituted where there are no ULNs. Levels exceeding either the ULNs or the OTR guidelines have been indicated in bold and underlined. The concentration contour maps for each of the inorganic elements in soil are included as Figures 31 to 51.

There were only a few exceedences of the soil guidelines. The exceedences included Mn at Site 1, Mg at Sites 1, 2, 8, 28 and 31, Mo at Site 1, Sr at Site 22, and Hg at Sites 2 and 22.

Mn, Mo and Mg soil concentrations were not related to Laidlaw. However, Hg and Sr gradients were less clear. The contours for these two elements were very similar; both had localized elevations at a site immediately north of Laidlaw and at one site at the extreme south of the sampling grid. Had it not been for the elevated concentrations at the one south site (2), then the data would suggest a localized concentration gradient relative to Laidlaw.

The soil and vegetation Sr data are not consistent. The soil and vegetation Hg data do not appear to be strongly correlated either. Therefore, even though the Hg foliar data indicates that the Laidlaw facility is a source of Hg emissions, the soil data is inconclusive, although suggestive. Additional monitoring is required to 1) confirm ambient air Hg concentrations via tree foliage, and 2) to evaluate the potential accumulation of Hg in surface soil.

Organic Data

Dioxins and Furans

Dioxins and furans, while never deliberately manufactured, may be formed whenever chlorinated compounds are incinerated. Therefore, soils were collected from a limited number of sites and analyzed for dioxins and furans as a screening-level check on emissions of these compounds from the Laidlaw facility. The results of the analyses are summarized in Table 4. The data are expressed in picograms of PCDD/PCDF per gram of sample (parts per trillion, or ppt). The data are summarized by total concentration in each congener group (isomers with the same number of atomic substitutions). For example, the congener T_4CDD stands for tetra-chlorinated dibenzo p-dioxin, meaning that there are 4 chlorine atoms attached to the ring structure that forms the basis of the dioxin molecule. Furans, although distinct, are associated with dioxins and coded in the same way. Therefore, *dioxin* and *furan* actually refer to classes of compounds which in turn refer to a large number of similar compounds. Generally, furans are less toxic than dioxins and toxicity decreases with increasing degree of chlorination. The most often discussed dioxin compound and the isomer considered to be the most toxic is 2,3,7,8-T_4CDD. Concentrations of individual 2,3,7,8-substituted isomers of dioxins and furans in soils are also presented in Table 4.

Because of the varying toxicities and relative abundance of the isomers and the congener groups, a system has been developed to combine the individual dioxin and furan results into one number that expresses the toxicity in relation to the most toxic of the compounds, 2,3,7,8-T_4CDD. This is referred to as the TEQ, or Toxic Equivalent. The dioxin and furan data in Table 4 were converted to TEQs using the International Toxicity Equivalency Factors[3] and the isomer substitution formula derived by the MOEE Standards Development Branch[4]. An interim guideline of 1000 pg/g TEQ for residential/parkland soil has been proposed[5].

The high resolution of the MOEE dioxin laboratory permits the detection of extremely low concentrations of dioxins and furans in soil. With few exceptions (T_4CDD at Sites 24 and 33), measurable concentrations of all congeners were detected in soils collected from all sample sites. The mean TEQ for the 5 sites located downwind of the facility was 0.14 pg/g compared to a TEQ of 0.15 pg/g for the upwind control site. In no case did the TEQ exceed the guideline of 1000 pg/g for residential/parkland soils. In addition, the concentrations of all congener groups were well within the range of concentrations detected in background rural and urban Ontario soils (OTR_{98}= 5pg/g)[7]. The limited data, therefore, do not implicate Laidlaw as a source of dioxins/furans in soil in the vicinity of the facility.

PCBs

The current guidelines for PCBs in soils were developed by the Canadian Council of

Ministers of the Environment and referred to as the "Interim Guidelines for PCBs in Soils"[6]. The interim maximum acceptable concentrations (on a dry weight basis) of PCBs in soils are 0.5 µg/g for agricultural soil (including home gardens), 5.0 µg/g for non-agricultural soil (eg. residential or public access) and 50 µg/g for industrial/commercial soil. The soils sampled in this survey would classify as non-agricultural (residential) soils and should be considered in the context of the CCME guideline of 5 µg/g.

The PCB concentrations in soils collected in this study were all below the analytical detection limit of 0.02 µg/g.

SUMMARY AND CONCLUSIONS

Maple tree foliage was collected in 1993 and 1994 from 20 previously established sites in the vicinity of Laidlaw Environmental Services and analyzed for 21 inorganic elements. Generally, concentrations of elements were below the MOEE ULN guidelines for rural foliage. There were, however, distinct spatial concentration gradients for Al, Cd, Cu, Ba, Fe, Na and Hg in vegetation that were associated with the Laidlaw facility. The gradient for Hg was particularly notable because the concentrations of mercury in some of the survey sites close to the facility exceeded the ULN guideline for foliage.

Soil (0-5 cm) was collected from the same 20 sites in 1993 and analyzed for the same 21 elements. Like maple foliage, there were few exceedences of the ULNs for surface soil and no spatial gradients of that could be associated with the Laidlaw facility. This concurs with the findings of earlier studies around the facility including and associated contour mapping. Hg concentrations in surface soil exceeded the ULN guideline at two sample sites, but because one of these was at the south edge of the sample grid, the soil Hg concentration gradient was only suggestive of source-related Hg deposition. Continued monitoring is required before it can be concluded that soil Hg accumulation has occurred or whether these data simply represent marginal elevations of local background.

A limited survey of organic contaminants in soils in the vicinity of the facility also found that concentrations of dioxins, furans and PCBs were within background limits and not detectibly elevated near the facility.

It is concluded from this survey that the Laidlaw Environmental Services facility, either through emissions from its incinerator and/or fugitive emissions from landfill, is having a marginal but measurable impact on the surrounding environment. Concentrations in vegetation and particularly in soil remain low and would not interfere with the normal use of the land. Because of the apparent trend toward increased concentrations of Hg and other elements in vegetation near the facility it is recommended that annual vegetation surveys be continued with provisions for periodic soil sampling.

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Table 1: Concentrations* of Elements in Silver Maple Foliage Collected in the Vicinity of Laidlaw Environmental Services, Corunna - September 1993.

Site	Cu	Ni	Pb	Zn	Fe	Mn	Al	As	Ba	Cd	Cl	Co	Cr	Hg	Mg	Mo	Na	Sb	Se	Sr	V
1	3.7	0.8T	DL	17	101	24	51	DL	4.2	0.12T	**0.17**	DL	1.0T	0.06	2200	DL	6T	DL	DL	21	DL
2	3.5	0.8T	DL	20	99	12	56	DL	5.3	DL	**0.32**	DL	DL	0.05T	3600	DL	5T	DL	DL	25	DL
3	8.9	0.9T	DL	49	180	17	140	DL	8.7	0.14T	0.074	DL	DL	0.05T	3300	DL	23	DL	0.45T	26	0.8T
4	5.0	1.2T	1.6T	37	230	41	160	DL	7.1	0.21T	**0.25**	DL	DL	0.06	4200	DL	27	DL	DL	30	1.0T
6	5.2	0.8T	1.2T	37	210	66	130	DL	5.8	DL	**0.25**	DL	0.6T	0.09	4100	DL	13	DL	DL	37	0.7
8	6.0	DL	DL	32	99	11	62	DL	3.9	DL	0.11	DL	DL	0.04T	2800	DL	8T	DL	DL	21	DL
11	7.5	0.7T	1.7T	27	150	42	100	DL	8.2	0.1T	**0.5**	0.3T	DL	0.07	4000	DL	17	DL	0.27T	53	0.8T
13	3.5	DL	DL	38	130	**120**	46	DL	8.9	0.23T	**0.17**	DL	DL	0.06T	3700	DL	13	DL	0.23T	32	DL
15	8.8	1.0T	3.2	46	340	52	260	DL	11	0.31T	**0.56**	DL	1.5T	0.1	3600	0.2T	**62**	DL	DL	35	1.1T
17	5.2	0.6T	1.6T	34	170	30	114	DL	4.8	DL	0.081	DL	DL	0.05T	2900	DL	12	DL	0.22T	25	DL
20	2.9	0.9T	1.3T	30	140	11	66	DL	7.0	0.14T	**0.52**	DL	DL	0.03T	2600	DL	15	DL	0.23T	23	1.1T
22	12	0.7T	1.6T	34	150	35	98	DL	7.9	0.22T	0.13	DL	DL	0.07	3100	DL	19	DL	0.28T	24	0.5T
23	3.1	0.8T	1.1T	31	103	10	70	DL	5.4	DL	**0.23**	DL	DL	0.06	3100	DL	6T	DL	0.25T	26	0.5T
24	6.8	0.8T	0.2T	39	190	**120**	120	DL	12	0.24T	**0.4**	DL	DL	**0.12**	4300	DL	24	DL	0.3T	37	0.6T
27	14	0.8T	1.1T	33	93	9.0	43	DL	3.2	0.17T	**0.18**	DL	DL	0.06T	2100	DL	7T	DL	0.4T	22	0.6T
28	4.8	1.0T	1.0T	23	170	17	90	DL	6.6	0.15T	**0.54**	DL	DL	0.06	2100	DL	13	DL	DL	15	0.8T
29	7.9	DL	0.7T	30	79	36	44	DL	6.5	0.1T	**0.61**	DL	DL	0.05T	2400	DL	5T	DL	DL	16	DL
30	6.7	DL	1.2T	48	91	17	68	DL	5.3	DL	0.015	DL	DL	0.07	2900	DL	13	DL	DL	26	0.7T
31	3.5	0.6T	0.5T	35	130	10	100	DL	7.0	0.24T	0.13	DL	DL	0.06T	3000	DL	30	DL	DL	30	0.7T
33	3.2	DL	0.7T	23	101	35	66	DL	5.4	DL	**0.98**	DL	DL	0.04T	2700	DL	**54**	DL	DL	44	DL
ULN (Rural)	20	5	30	250	500	100[1]	500	0.5	NG	1	0.15	2	8	0.1	7000	1.5	50	0.3	0.5	NG	5

* ug/g dry weight, mean of duplicate samples and analysis (except for Cl expressed in %)
1 No rural ULN, urban ULN substituted.
NG No guideline currently available.
T A measurable trace amount. Interpret with caution.
DL Less than analytical detection limit.
ULN Upper Limit of Normal Phytotoxicology guideline for rural tree foliage.
Values underlined and in bold exceed established ULN guideline.

Table 2: Concentrations* of Elements (µg/g) in Silver Maple Foliage Collected in the Vicinity of Laidlaw Environmental Services, Corunna - September 1994.

Site	Cu	Ni	Pb	Zn	Fe	Mn	Al	As	Ba	Cd	Cl	Co	Cr	Hg	Mg	Mo	Na	Sb	Se	Sr	V
1	7.6	0.7T	DL	23	101	49	50	DL	7.9	0.16T	**0.6**	0.5T	0.7T	DL	3300	DL	14	DL	DL	155	DL
2	4.1	DL	DL	18	80	13	53	DL	7.0	DL	**0.32**	DL	DL	0.05	3800	DL	14	DL	DL	40	DL
3	9.6	0.6T	1.0T	51	106	16	78	DL	8.5	DL	0.045	DL	DL	DL	3200	DL	17	DL	DL	30	DL
4	5.3	0.7T	DL	36	160	60	98	DL	8.9	0.27T	**0.19**	0.5T	0.6T	0.04T	4000	DL	34	DL	DL	36	DL
6	5.7	0.7T	DL	27	180	58	130	DL	5.8	0.19T	**0.19**	0.5T	0.7T	**0.11**	3600	DL	14	DL	DL	32	0.5T
8	8.0	0.7T	DL	46	140	42	82	DL	6.9	0.19T	0.12	0.5T	DL	0.05T	3500	DL	12	DL	DL	39	DL
11	5.7	0.5T	1.2T	24	115	59	109	DL	6.1	DL	**0.71**	DL	DL	0.04T	2900	DL	23	DL	DL	29	DL
13	5.7	0.8T	DL	40	220	**110**	110	DL	9.5	0.21T	**0.25**	0.2T	0.5T	0.08	3600	DL	24	DL	DL	33	0.5T
15	6.9	0.9T	1.2T	41	330	59	230	0.49T	12	0.3T	**0.7**	0.5T	1.8	**0.29**	3900	DL	47	DL	DL	43	0.8T
17	6.8	0.7T	0.7T	38	190	44	127	DL	6.5	0.19T	0.07	0.5T	0.7T	0.05T	3300	DL	19	DL	DL	43	0.6T
20	7.1	0.5T	1.0T	26	150	50	101	DL	6.1	0.12T	**0.23**	DL	DL	DL	3500	0.2T	18	DL	DL	45	0.6T
22	15	0.6T	1.2T	32	150	31	98	DL	7.7	DL	0.11	DL	DL	0.04T	3100	DL	26	DL	DL	25	DL
23	3.7	DL	DL	35	150	27	71	DL	5.5	DL	**0.4**	DL	DL	0.03T	4200	DL	14	DL	DL	36	DL
24	11	0.8T	1.4T	40	190	100	130	DL	9.4	DL	**0.37**	DL	DL	**0.14**	3500	DL	25	DL	DL	32	0.6T
27	12	0.7T	DL	59	97	26	50	DL	6.1	DL	**0.16**	DL	DL	0.03T	2700	DL	16	DL	0.5T	67	DL
28	5.8	DL	0.5T	30	170	30	73	DL	8.9	DL	**0.43**	DL	DL	0.03T	2300	DL	23	DL	DL	22	DL
29	7.8	DL	DL	45	86	30	34	DL	9.3	DL	**0.42**	DL	0.5T	0.03T	3300	DL	11	DL	DL	26	DL
30	9.7	DL	0.6T	45	116	32	64	DL	6.9	DL	0.05	DL	DL	0.06	3300	DL	16	DL	DL	32	DL
31	4.5	DL	0.8T	33	112	16	54	DL	6.6	DL	0.08	DL	DL	0.04T	3200	0.2T	18	DL	DL	30	DL
33	4.1	0.5T	0.6T	21	95	21	42	DL	5.5	DL	**0.34**	DL	DL	0.03T	3100	DL	9	DL	DL	18	DL
ULN (Rural)	20	5	30	250	500	100[1]	500	0.5	NG	1	0.15	2	8	0.1	7000	1.5	50	0.3	0.5	NG	5

* ug/g dry weight, mean of triplicate samples and analysis (except for Cl expressed in %)
1 No rural ULN, urban ULN substituted..
NG No guideline currently available.
T A measurable trace amount. Interpret with caution.
DL Less than analytical detection limit.
ULN Upper Limit of Normal Phytotoxicology guideline for rural tree foliage.
Values underlined and in bold exceed established ULN guideline.

Table 3: Concentrations* of Elements in Surface Soil (0-5 cm) Collected in the Vicinity of Laidlaw Environmental Services, Corunna - September 1993.

Site	Cu	Ni	Pb	Zn	Fe	Mn	Al	As	Ba	Cd	Cl	Co	Cr	Hg	Mg	Mo	Na	Sb	Se	Sr	V
1	26	41	39	85	24500	**740**	17500	7.4	89	1.25	5.4	14.5	29	0.06T	**12000**	2.2T	105	0.5T	1.10	41	40
2	32	25	91	130	17000	475	17000	3.8	140	1.04T	37.0	9.4	28	**0.23**	**11000**	DL	98	0.5T	1.15	62	34
3	17	21	20	62	17000	265	16000	4.0	78	0.78T	41.3	8.0	24	0.09	8800	DL	77	0.3T	1.07T	33	35
4	13	18	25	60	15500	330	13950	4.1	65	0.52T	16.2	7.4	20	0.06T	7000	0.7T	43	0.4T	0.64T	23	33
6	13	16	22	59	12500	200	11000	4.0	51	0.65T	22.3	5.9	17	0.08	5200	0.9T	41	0.4T	0.70T	20	28
8	16	21	18	53	15500	325	13500	4.1	60	0.56T	13.0	8.1	20	0.05T	**13000**	1.2T	76	0.3T	0.88T	41	31
11	19	22	30	69	14000	230	13000	4.6	61	0.65T	37.8	7.4	20	0.07	10000	1.0T	80	0.3T	0.35T	32	27
13	18	24	21	64	17000	240	16000	5.8	69	0.83T	19.9	8.4	24	0.05T	7200	1.1T	64	DL	0.36T	21	36
15	18	21	35	86	16000	260	15000	4.3	72	0.9T	44.3	8	23	0.1	7000	1.2T	70	0.5T	0.8T	26	32
17	17	20	31	70	16000	270	14000	4.7	66	1.02T	17.6	6.8	22	0.08	6900	1.1T	56	0.4T	0.8T	23	35
20	19	22	46	89	16000	210	9500	4.4	74	0.9T	37.6	7.1	22	0.08	6900	1.1T	67	0.4T	0.87T	23	34
22	27	19	82	144	13500	230	13500	5.4	109	1.15	20.3	6.2	21	**0.17**	8300	1.3T	68	0.4T	0.54T	**66**	35
23	15	17	37	67	14000	200	13000	5.0	61	0.66T	44.3	6.6	19	0.07	7600	1.2T	68	0.3T	0.33T	22	30
24	13	18	24	52	14000	195	14000	4.0	62	0.62T	25.0	6.6	20	0.06T	5500	0.6T	41	0.3T	0.28T	17	30
27	22	26	21	74	16500	280	14500	5.3	61	0.95T	29.0	7.8	23	DL	7400	0.8T	58	0.4T	0.51T	25	33
28	22	23	40	96	16500	230	14500	6.0	73	0.91T	21.6	7.4	22	DL	**11500**	0.7T	86	0.4T	0.44T	31	32
29	20	22	22	88	15000	190	18000	3.6	80	0.8T	19.5	7	24	DL	8100	0.9T	74	0.4T	0.45T	25	33
30	12	15	21	52	12500	175	12000	4.4	52	0.56T	18.7	5.7	17	DL	7400	1.0T	49	DL	0.29T	19	26
31	15	16	27	56	10000	280	7900	4.0	41	0.65T	15.5	5.6	13	DL	**16500**	0.8T	100	0.3T	0.39T	52	20
33	16	13	16	43	8700	220	7000	4.3	34	0.56T	12.6	4.6	11	DL	9000	0.7T	63	DL	0.62T	26	19
ULN (Rural)	60	60	150	500	35000	700	30000[1]	10	160[1]	3	45[1]	25	50	0.15	10000	2	660[1]	1	2	64[1]	70

* ug/g dry weight, mean of duplicate samples and analysis
1 No rural ULN, OTR_{95} for rural parkland substituted.
T A measurable trace amount. Interpret with caution.
DL Less than analytical detection limit.
ULN Upper Limit of Normal Phytotoxicology guideline for urban tree foliage (see Appendix).
Values underlined and in bold exceed established ULN guideline.

Table 4 Analytical Results for Polychlorinated Dibenzo-p-dioxins (PCDD) And Polychlorinated Dibenzofurans (PCDF) in the Vicinity of Laidlaw Environmental Services, Corunna, 1993.

Sample description	SITE 2			SITE 11			SITE 13			SITE 15			SITE 23			SITE 24			SITE 33		
T4CDD	1.5[1]	ND(1)	ND(1)	ND(1)	1.0[1]	ND(1)	1.5[1]	ND(1)	ND(1)	ND(1)	1.5[1]	1.9[1]	1.1[1]	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
P5CDD	3.5[2]	1.8[1]	ND(2)	3.8[2]	ND(2)	3.1[2]	4.2[3]	1.1[1]	ND(1)	1.7[1]	2.6[1]	3.0[1]	1.9[1]	3.9[3]	1.5[1]	1.2[1*]	1.5[1]	1.4[1]	1.5[1]	1.0[1]	1.5[1]
H6CDD	24[5]	11[2]	20[4]	18[5]	19[5]	15[5]	28[6]	17[5]	11[5]	6.7[2]	14[5]	19[5]	19[5]	13[5]	11[5]	8.3[3]	9.9[4]	9.4[3]	13[4]	22[3]	14[4]
H7CDD	74[2]	48[2]	76[2]	63[2]	60[2]	48[2]	140[2]	78[2]	28[2]	25[2]	35[2]	38[2]	72[2]	25[2]	23[2]	25[2]	35[2]	34[2]	31[2]	40[2]	29[2**]
O8CDD	240	250	280	190	190	150	340	190	85	75	100	120	190	64	67	79	110	120	110	130	93
T4CDF	2.1[1]	ND(2)	5.0[1]	13[4]	7.5[2]	9.2[4]	2.9[2]	1.4[1*]	ND(5)	2.9[2]	4.5[3]	7.0[4]	2.8[2]	4.1[2]	1.3[1]	ND(3)	2.2[2]	2.2[2]	5.2[3]	9.6[4*]	5.5[3]
P5CDF	5.2[2]	4.6[2]	5.4[2]	38[6]	21[4]	24[4]	5.9[2]	4.4[2]	4.0[2]	4.6[2]	5.6[2]	6.9[2]	5.7[2]	10[5]	5.4[2]	2.9[2*]	3.8[2]	3.6[2*]	13[3]	40[5]	23[4]
H6CDF	12[4]	6.8[3]	11[4]	29[5]	19[4]	18[3]	19[4]	13[4]	4.9[2]	7.6[4]	12[5]	16[6]	12[4]	10[5]	6.0[3]	6.6[4]	7.3[4]	6.8[4]	13[5]	32[7]	17[4]
H7CDF	21[2]	12[2]	27[2]	40[2]	26[2]	24[2]	37[2]	24[2]	11[2]	9.9[2]	15[2]	16[2]	21[2]	7.3[2]	6.6[2]	8.0[2]	12[2]	13[2]	10[2]	5.3[1]	9.6[2]
O8CDF	22	15	35	60	35	32	30	190	7.5	7.4	14	16	22	6.8	6.0	9.8	15	14	12	14	12
2,3,7,8-T4CDD Toxic Equivalents***	0.168			0.133			0.156			0.160			0.155			0.117			0.138		
	2,3,7,8-Substituted Isomers																				
2,3,7,8-TCDD	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
1,2,3,7,8-PCDD	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	1.1	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
1,2,3,4,7,8-H6CDD	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	1.1	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
1,2,3,6,7,8-H6CDD	3.1	ND(2)	3.1	2.1	2.2	1.7	2.9	2.1	1.4	ND(1)	1.4	1.7	2.6	1.1	1.2	ND(1)	1.2	ND(1)	1.3	ND(2)	1.6
1,2,3,7,8,9-H6CDD	3.0	ND(1)	2.8	1.7	1.8	1.6	2.7	1.7	1.4	ND(1)	1.7	2.0	2.6	1.3	1.0	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
1,2,3,4,6,7,8-H7CDD	46	28	46	37	32	28	62	38	16	14	20	21	49	13	12	13	20	19	17	22	16
2,3,7,8-TCDF**	2.1	ND(2)	2.4	1.5	1.8	1.4	1.4	ND(1)	ND(1)	1.7	2.1	2.4	1.5	2.5	ND(1)	ND(1)	1.1	1.0	1.7	1.4	1.2
1,2,3,7,8-PCDF	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	1.5	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
2,3,4,7,8-PCDF	ND(1)	ND(1)	ND(1)	1.0	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	1.4	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	1.2	ND(1)
1,2,3,4,7,8-H6CDF	2.0	ND(2)	1.9	1.6	1.7	ND(1)	1.6	1.4	1.3	1.7	2.1	2.6	1.5	2.0	ND(1)	1.5	1.1	1.1	1.4	1.9	1.3
1,2,3,6,7,8-H6CDF	ND(1)	ND(1)	ND(1)	1.2	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	1.3	ND(1)	1.1	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	1.2	ND(1)
2,3,4,6,7,8-H6CDF	ND(1)	1.5	ND(1)	ND(2)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1).	1.5	1.7	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(2)	ND(1)
1,2,3,7,8,9-H6CDF	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
1,2,3,4,6,7,8-H7CDF	8.2	5.5	9.9	15	9.7	9.9	14	9.2	4.9	5.4	7.5	7.9	10	4.3	3.6	4.3	5.7	5.9	4.2	5.3	3.9
1,2,3,4,7,8,9-H7CDF	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)

- All concentrations expressed in ppt (parts-per-trillion; picograms (10^{-12} grams) of PCDD/PCDF per gram of sample).
  Values are corrected for recovery of isotopically labelled surrogate standards.
- "ND" Not detected. Detection limit in ppt given in brackets ( ).
- Superscripts indicate the number of isomers detected.

* Recoveries outside the range 25 to 150%; results are not to be used for regulatory compliance purposes.

** Maximum concentration due to chromatographic overlap.

*** 2,3,7,8-T4CDD Toxic Equivalents (TEQ) - the sum of the weighted TEQ factors. Interim guideline is 1000 pg/g for residential/parkland soils (Birmingham, 1991)

Figure 1: Sketch Map of Vegetation and Soil Sampling Locations in the Vicinity of Laidlaw Environmental Services Limited (1993/1994).

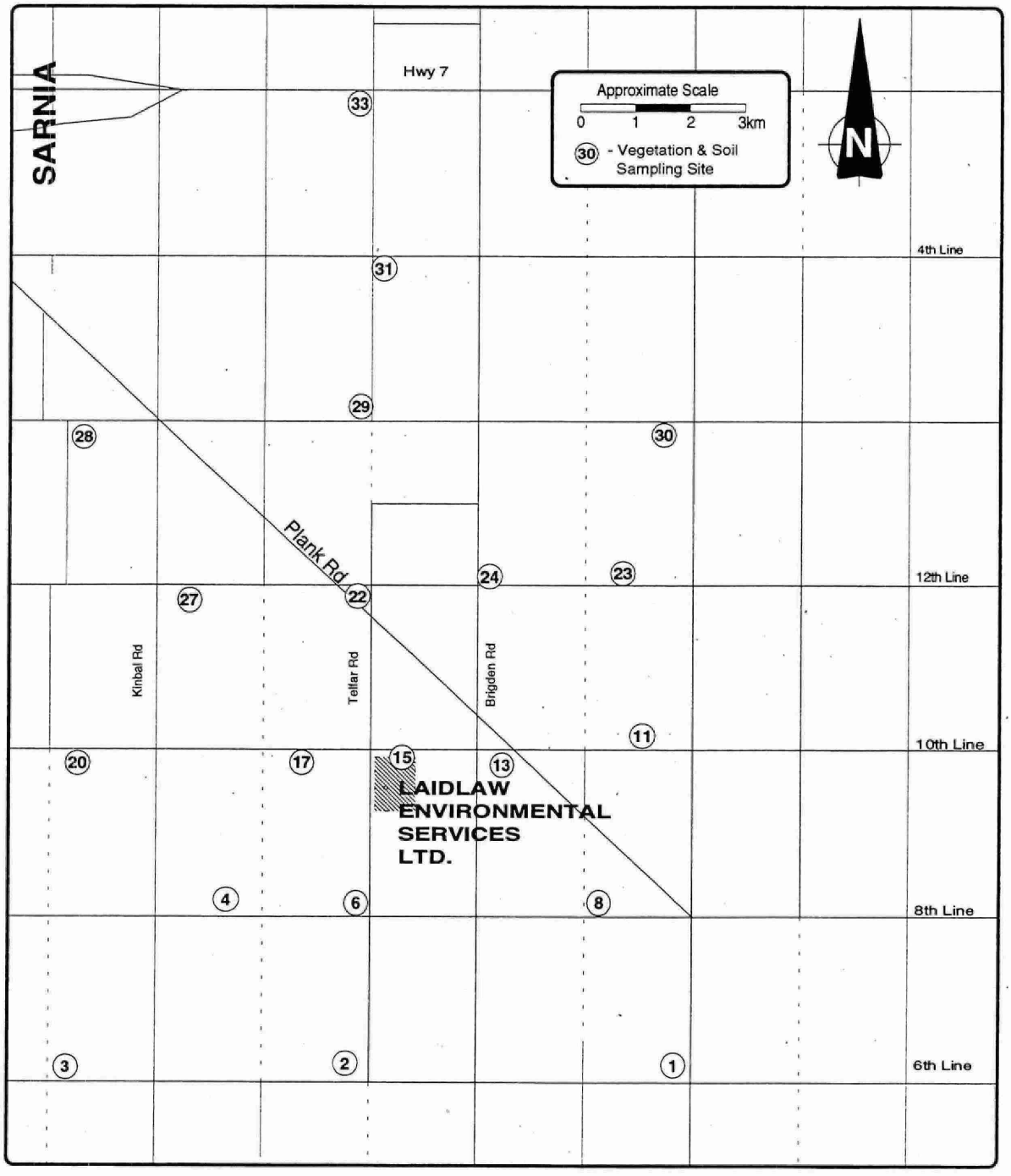


Figure 2: Wind Direction and Wind Speed Annual Normals for the Sarnia Meterological Station (Sarnia A) for the period 1967 to 1980.

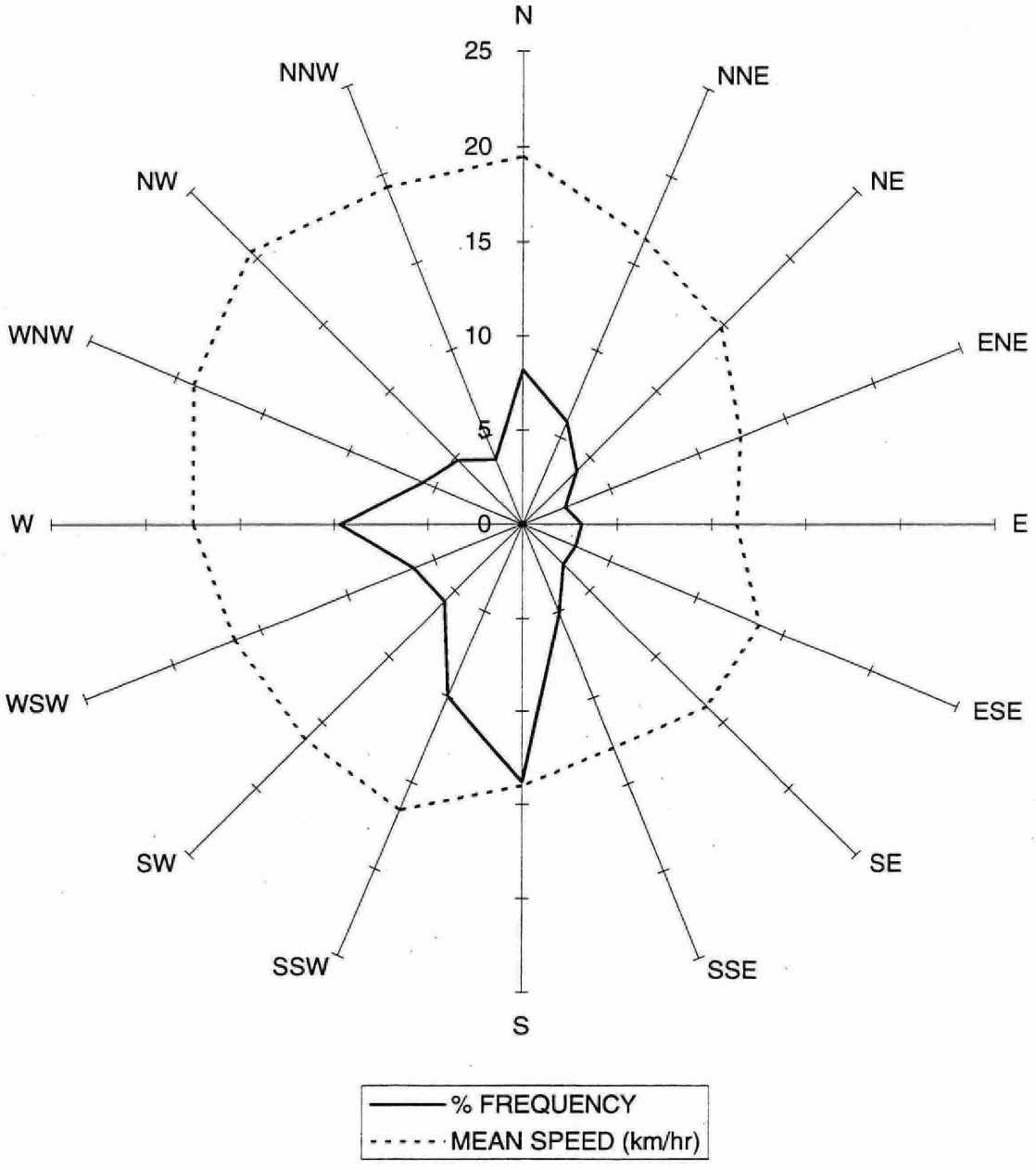


FIGURE 3 93 V HG

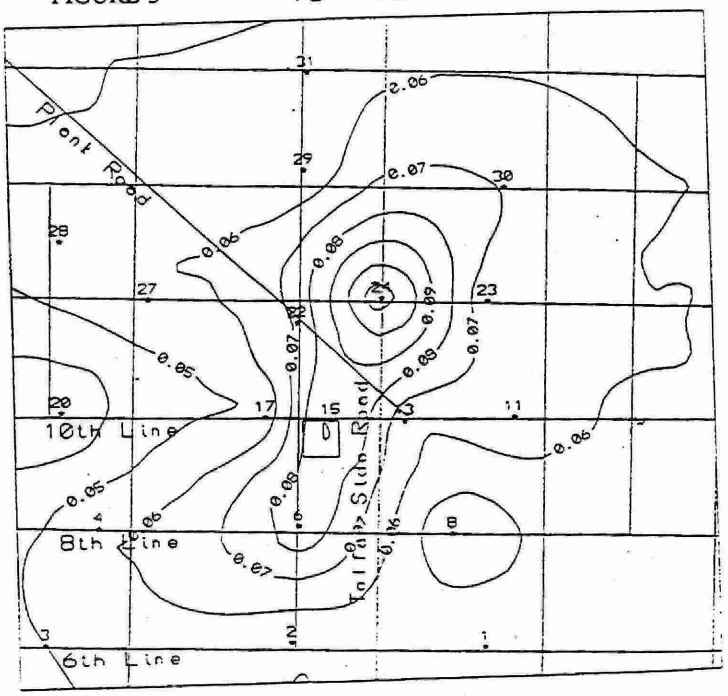


FIGURE 4 94 V HG

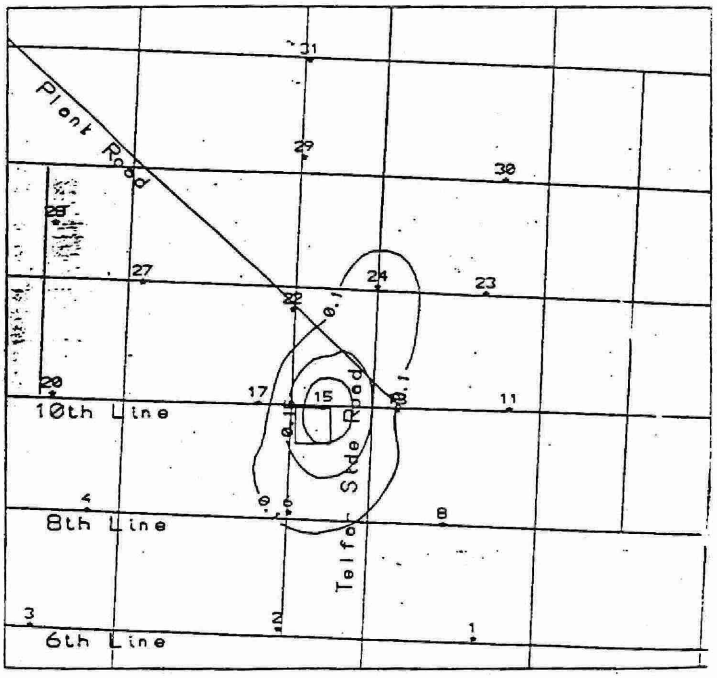


FIGURE 5 93 V NA

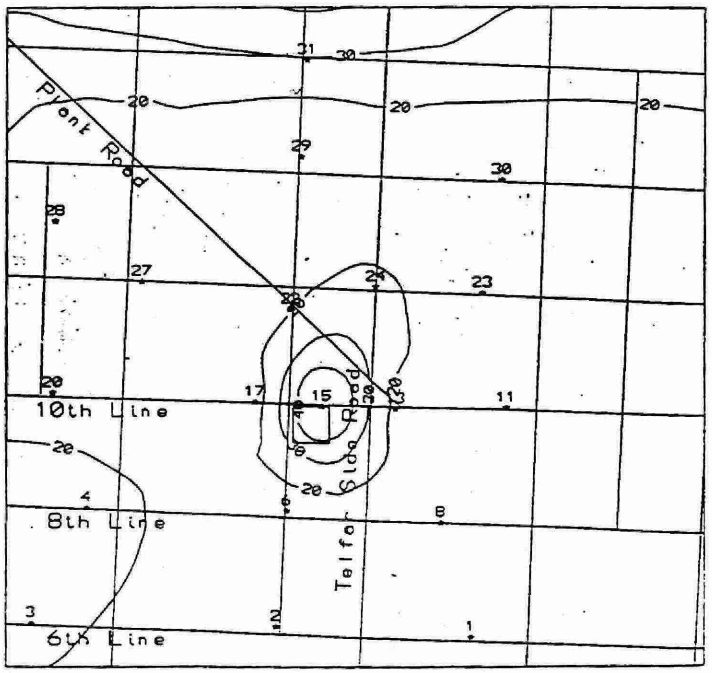
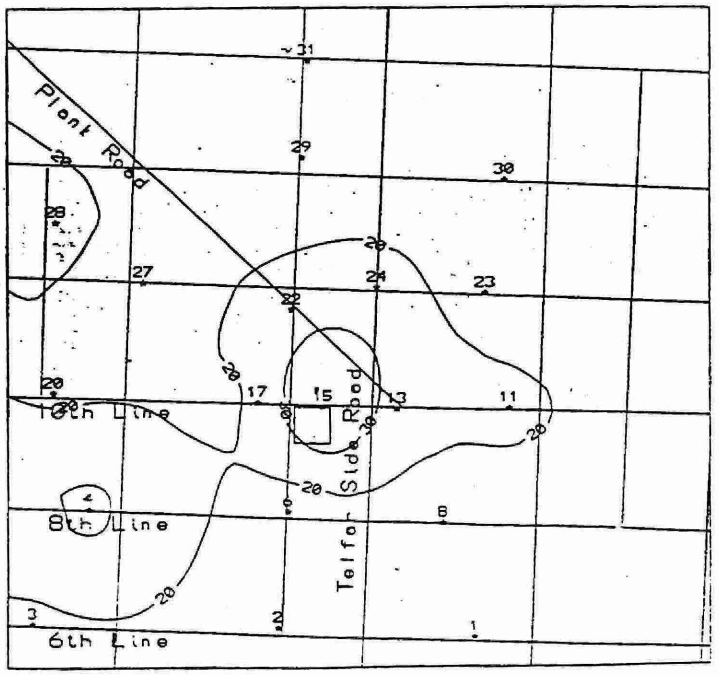


FIGURE 6 94 V NA



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations

FIGURE 7 93 V AL

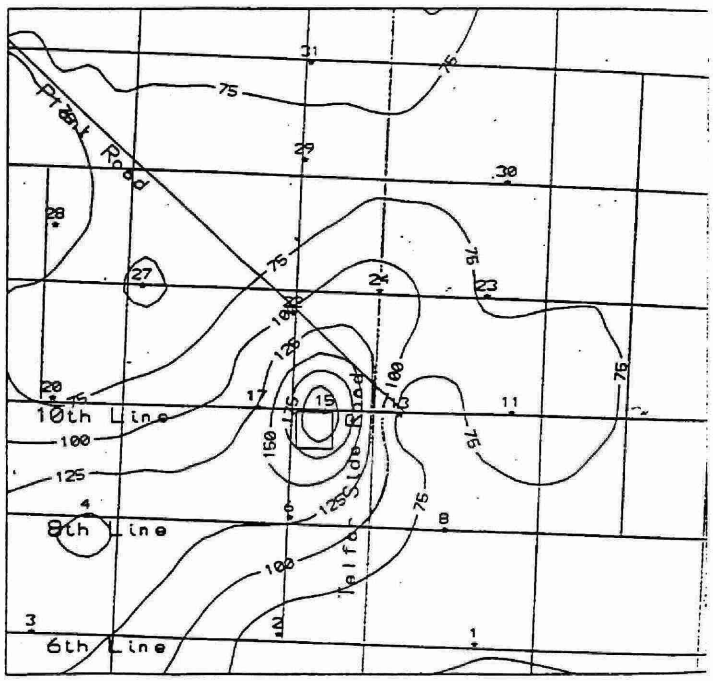


FIGURE 8 94 V AL

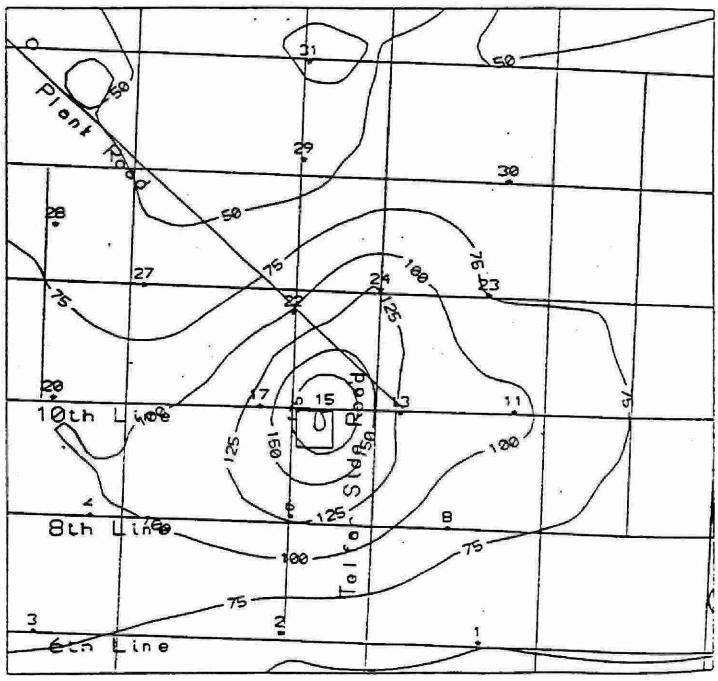


FIGURE 9 93 V BA

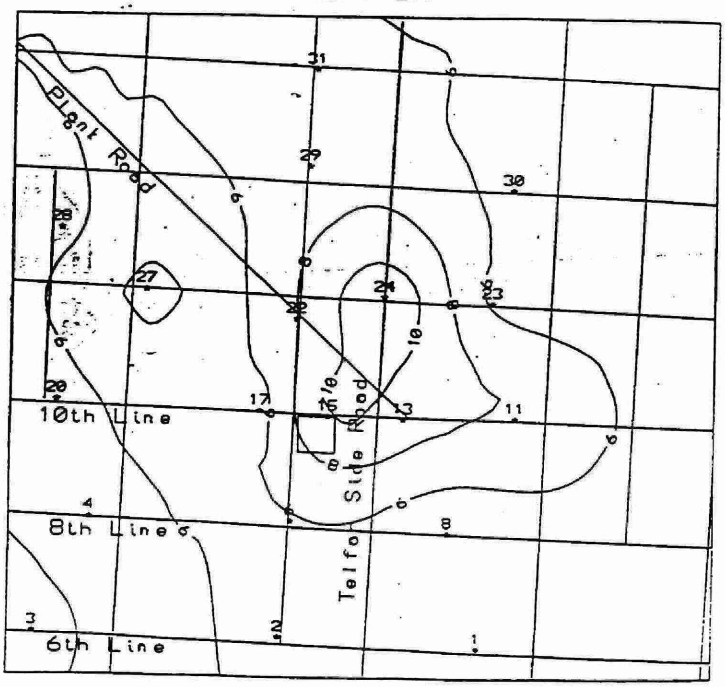
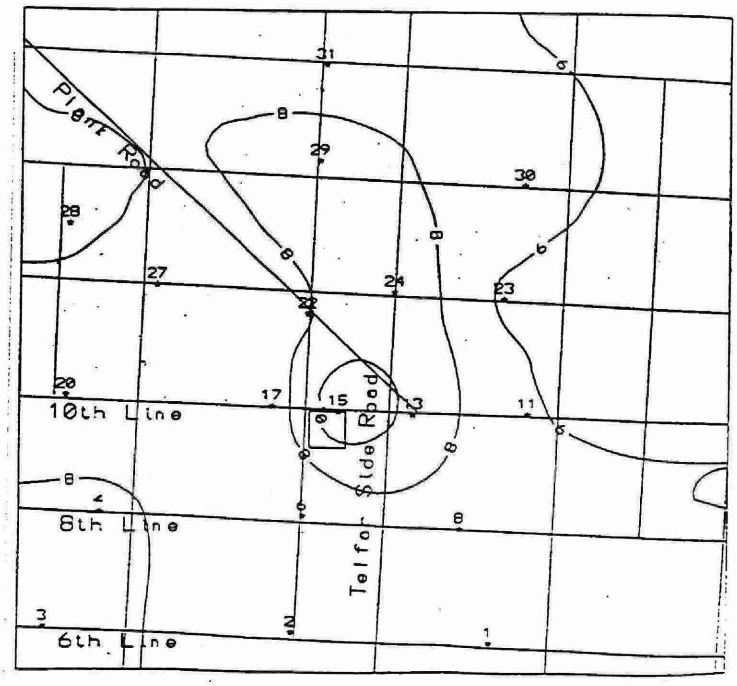


FIGURE 10 94 V BA



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations

FIGURE 11 93 V CU

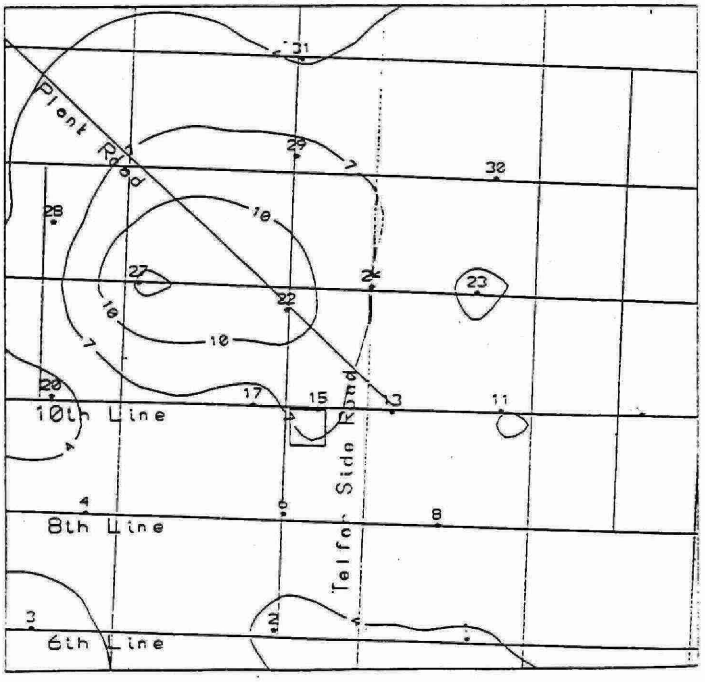


FIGURE 12 94 V CU

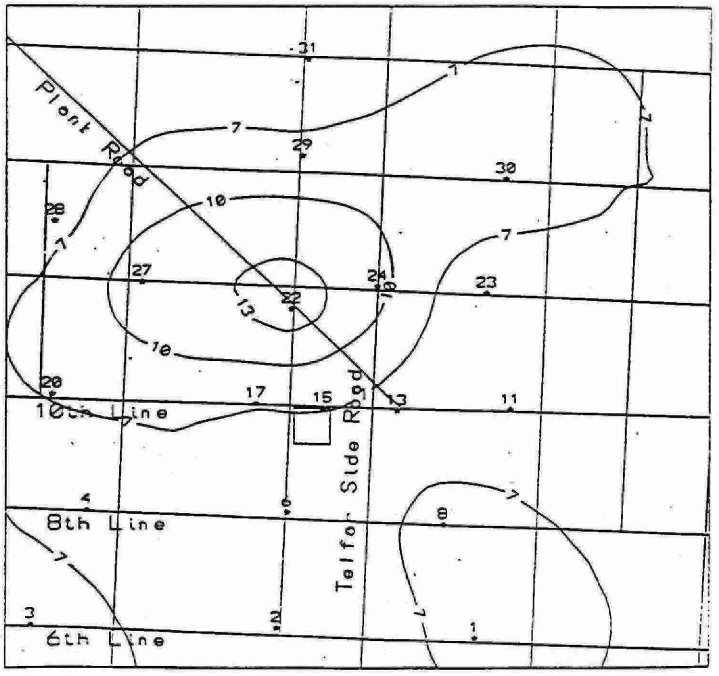


FIGURE 14 94 V CD

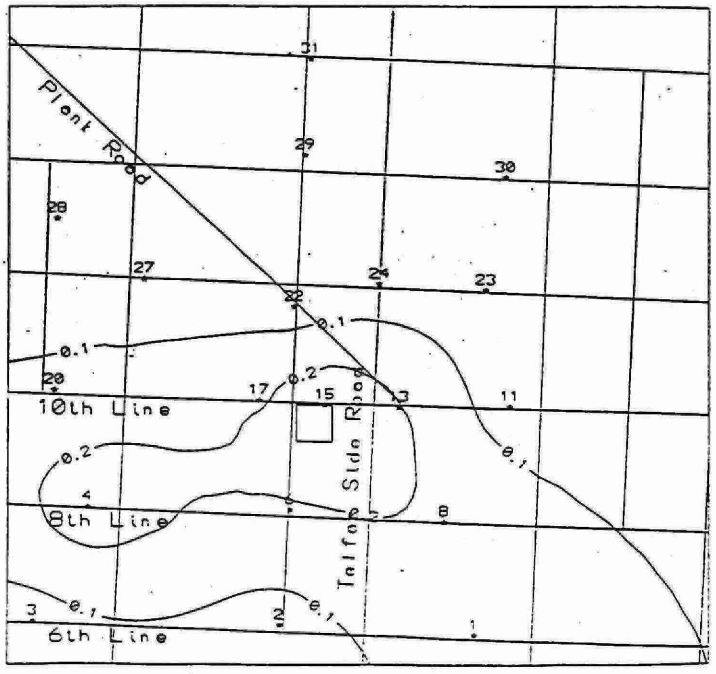
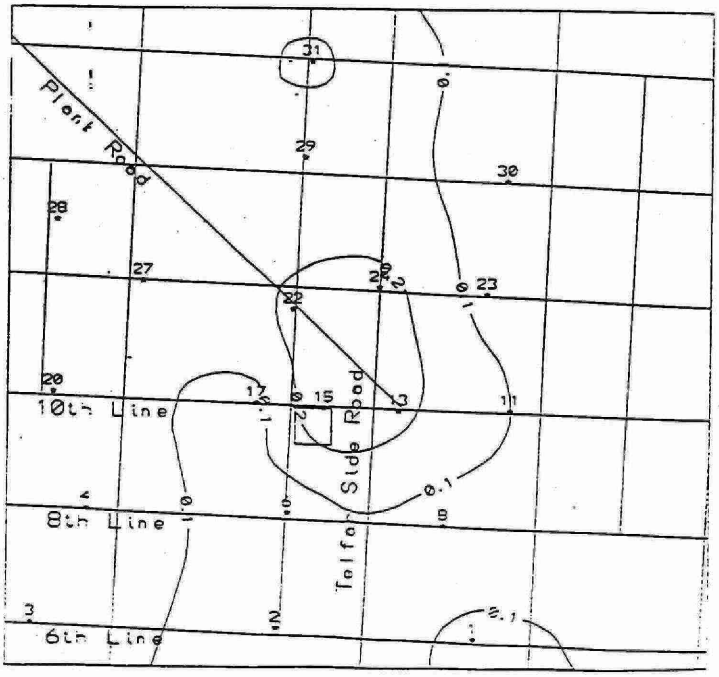


FIGURE 13 93 V CD



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations

FIGURE 15 93 V FE

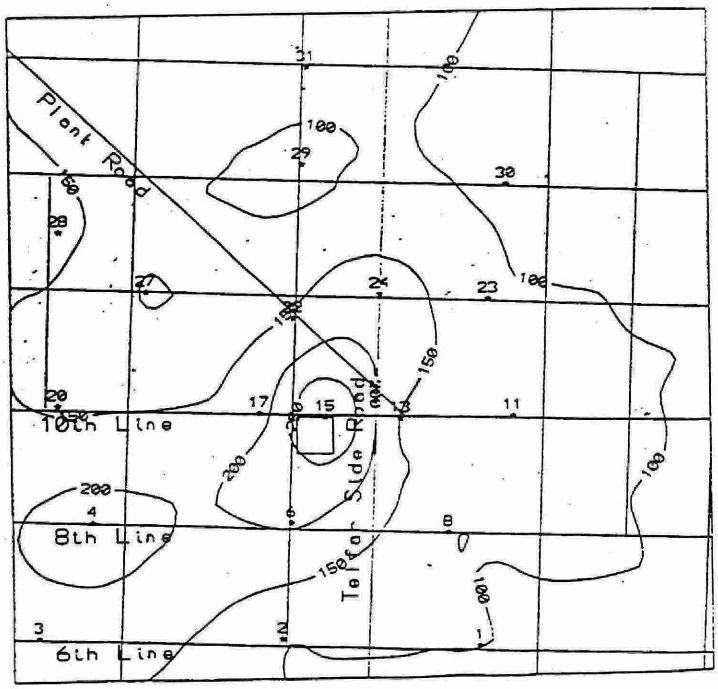


FIGURE 16 94 V FE

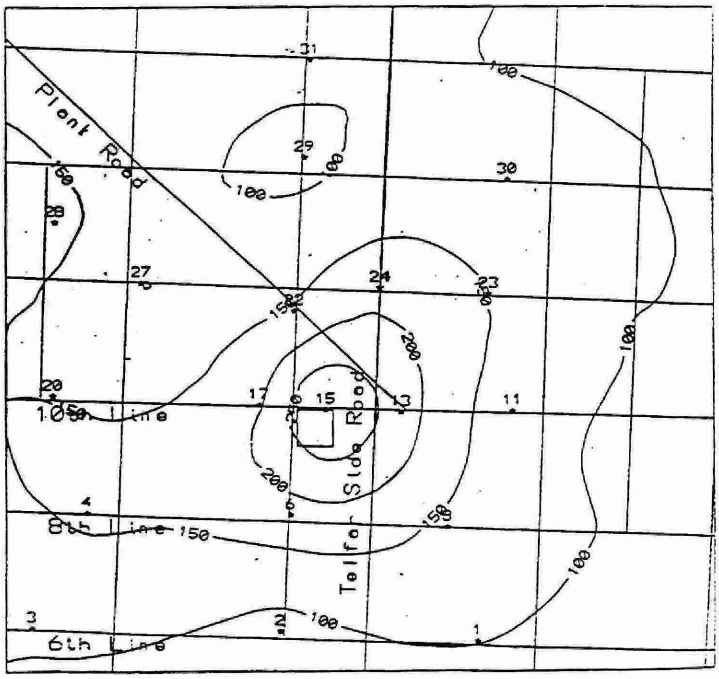


FIGURE 17 93 V MN

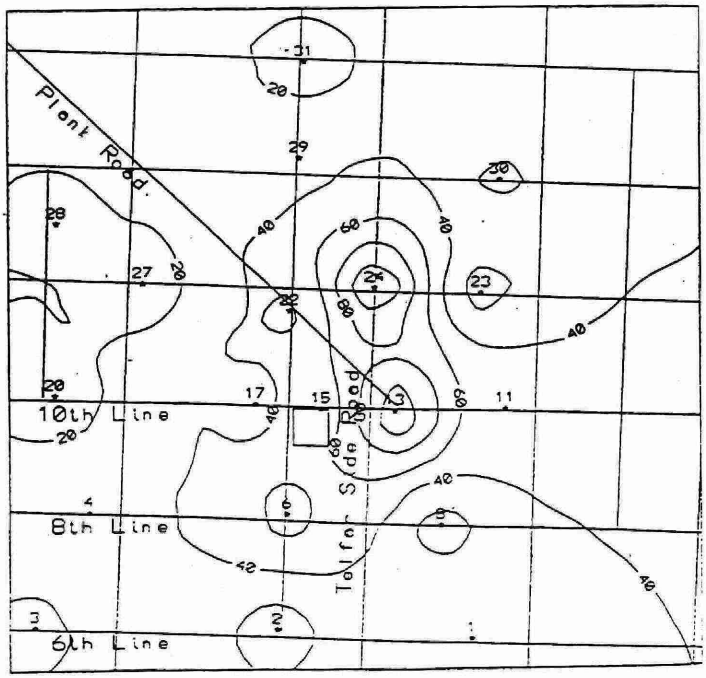
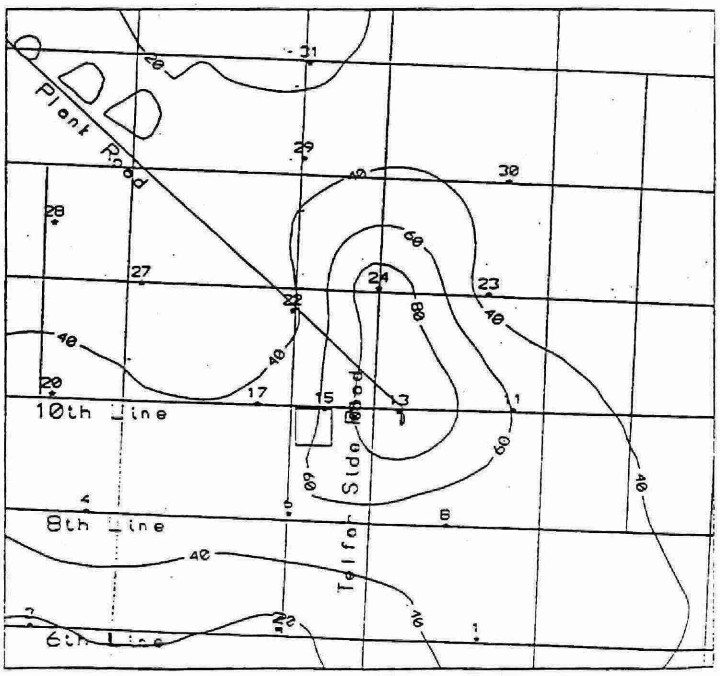


FIGURE 18 94 V MN



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations

FIGURE 19 93 V NI

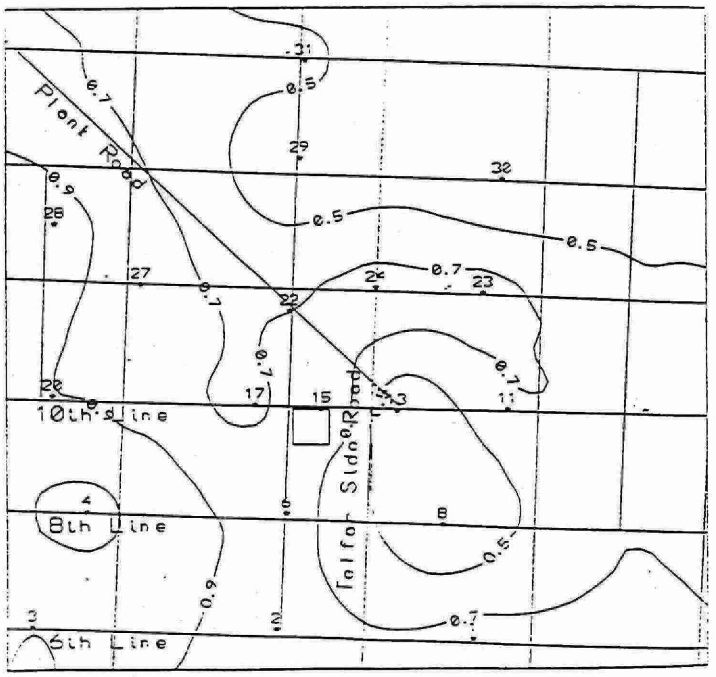


FIGURE 20 94 V NI

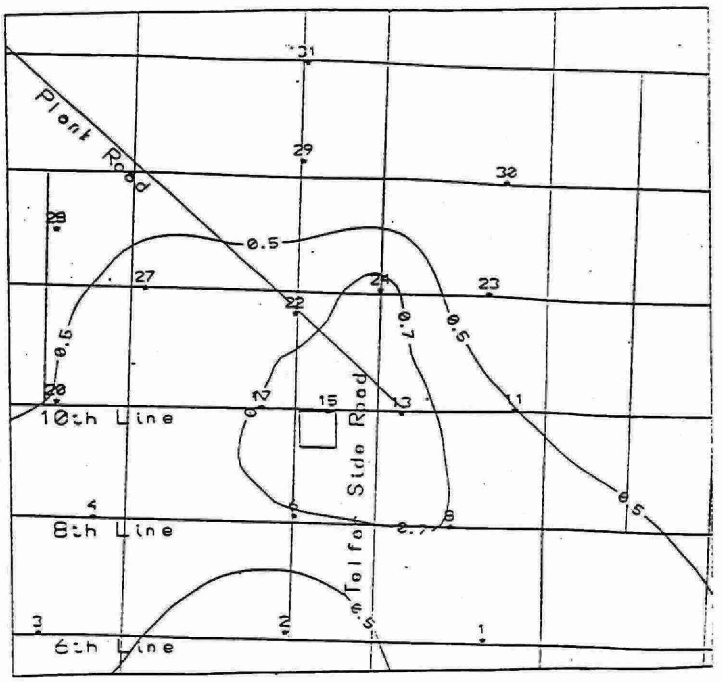


FIGURE 22 94 V PB

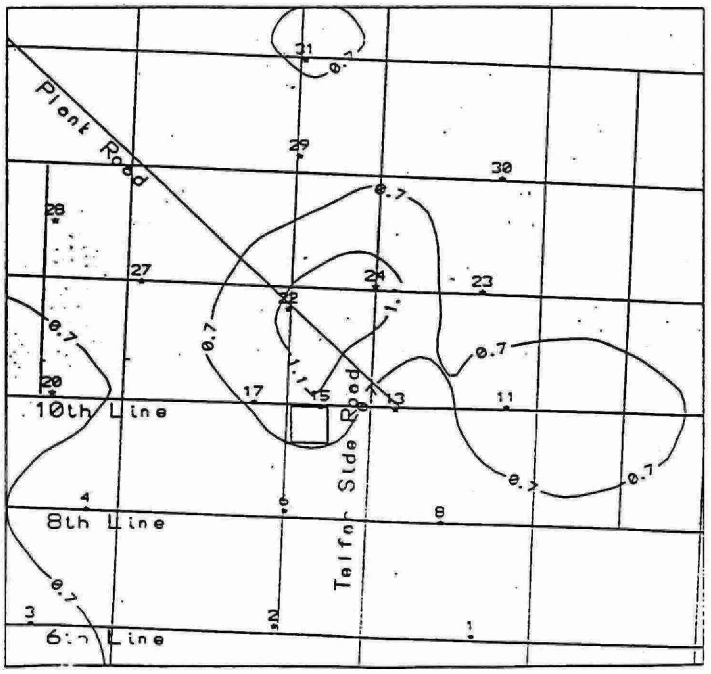
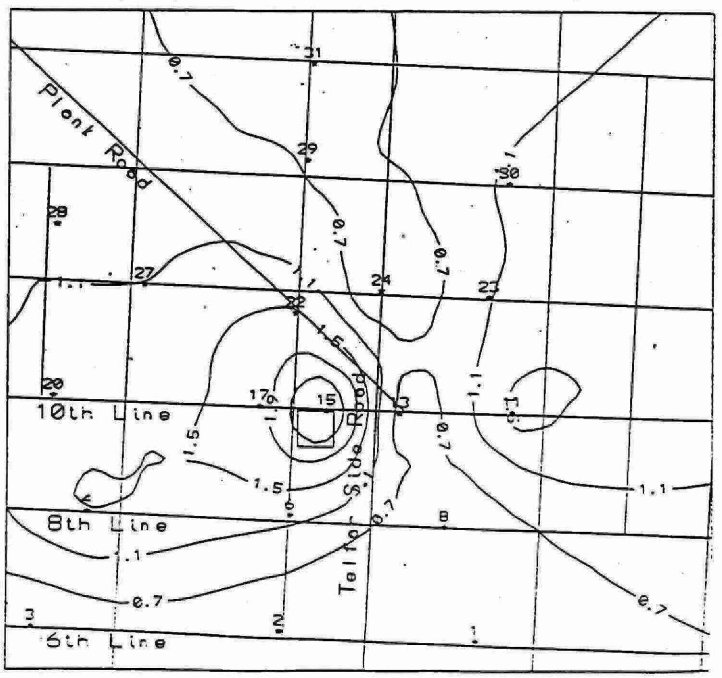


FIGURE 21 93 V PB



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations

FIGURE 23 93 V CL

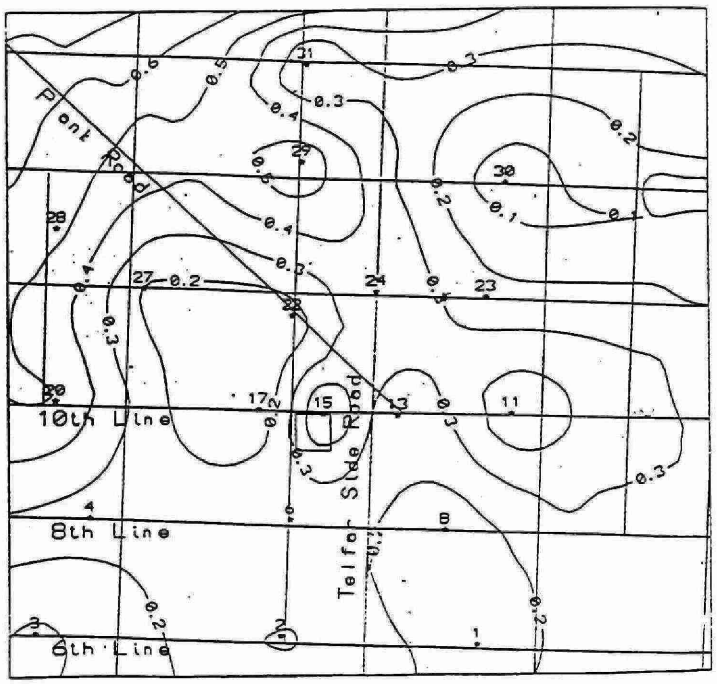


FIGURE 24 94 V CL

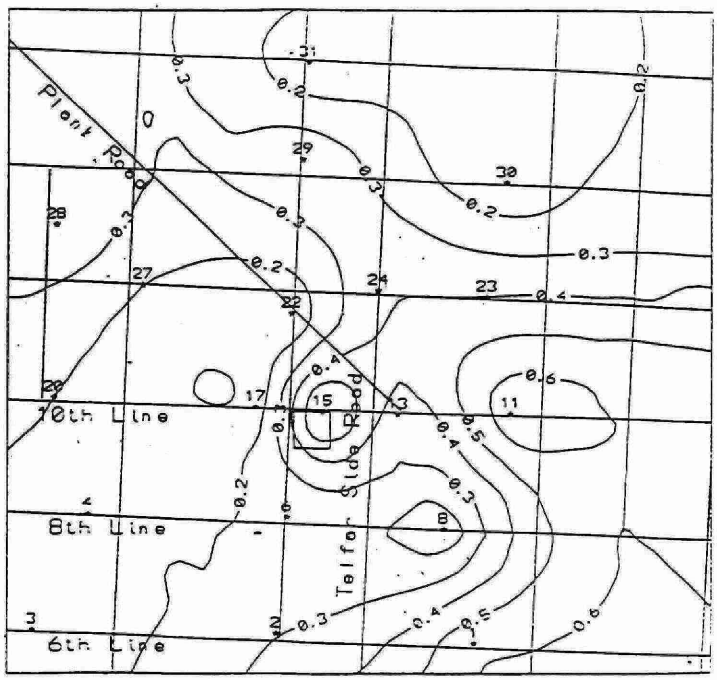


FIGURE 25 93 V MG

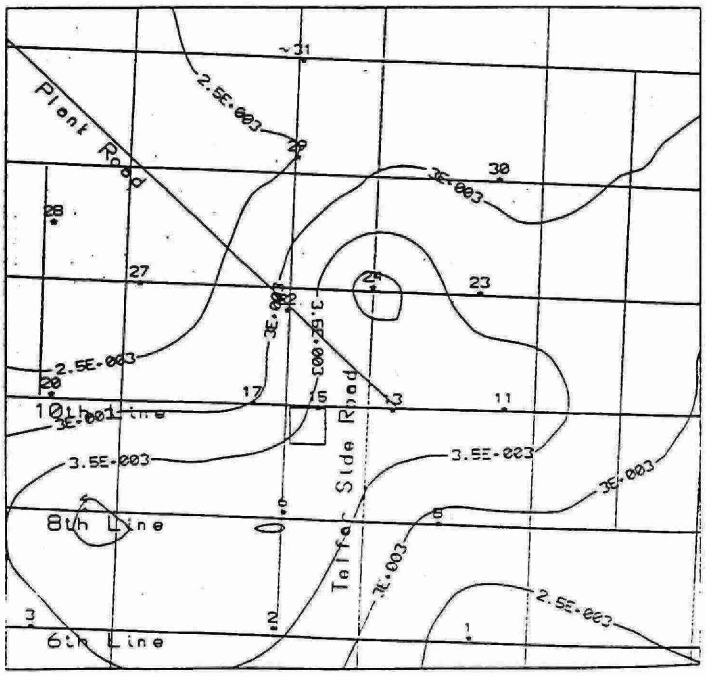
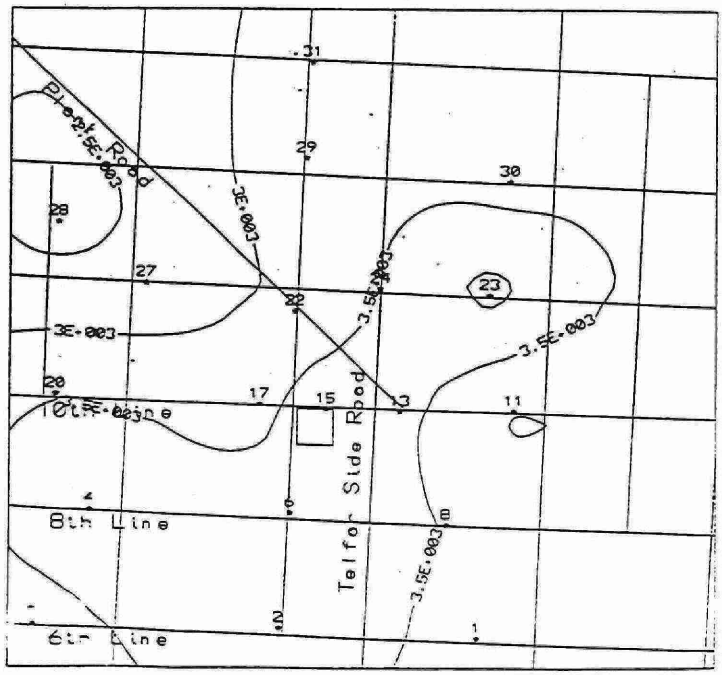


FIGURE 26 94 V. MG



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations

FIGURE 27 93 V SR

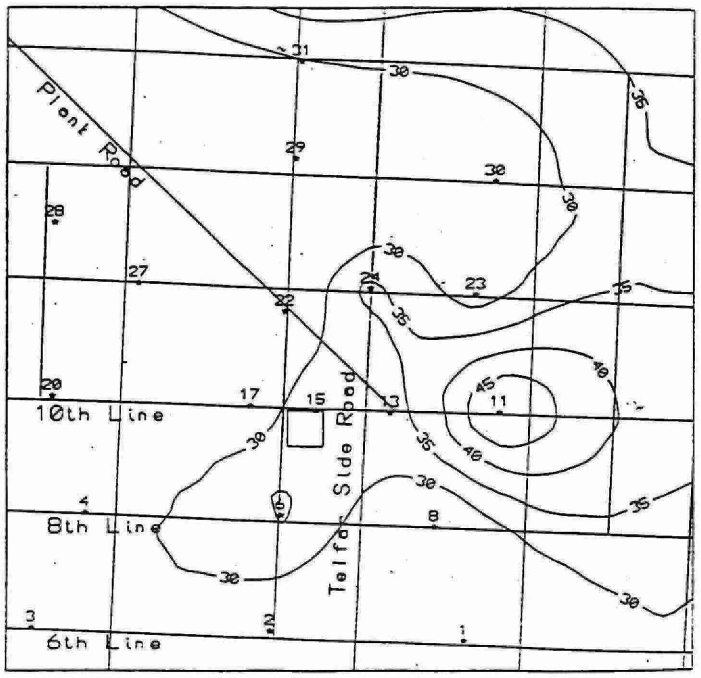


FIGURE 28 94 V SR

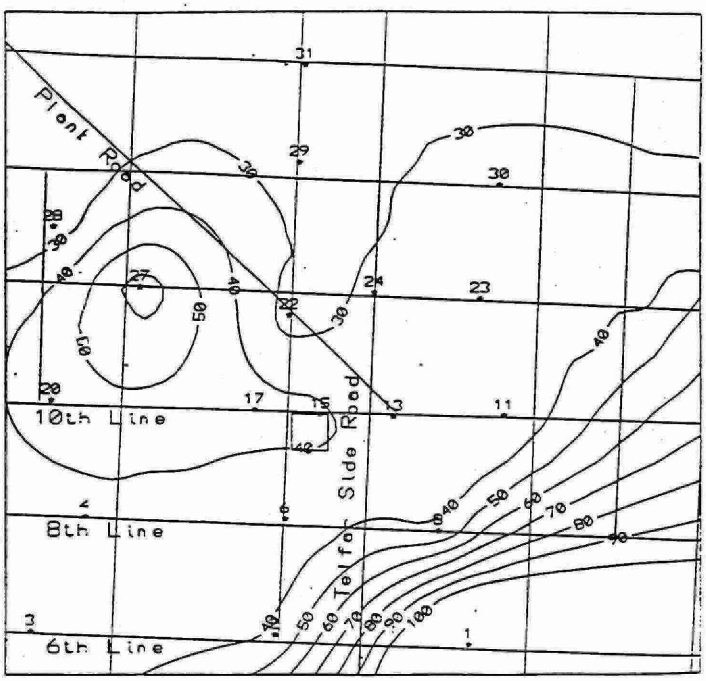


FIGURE 29 93 V ZN

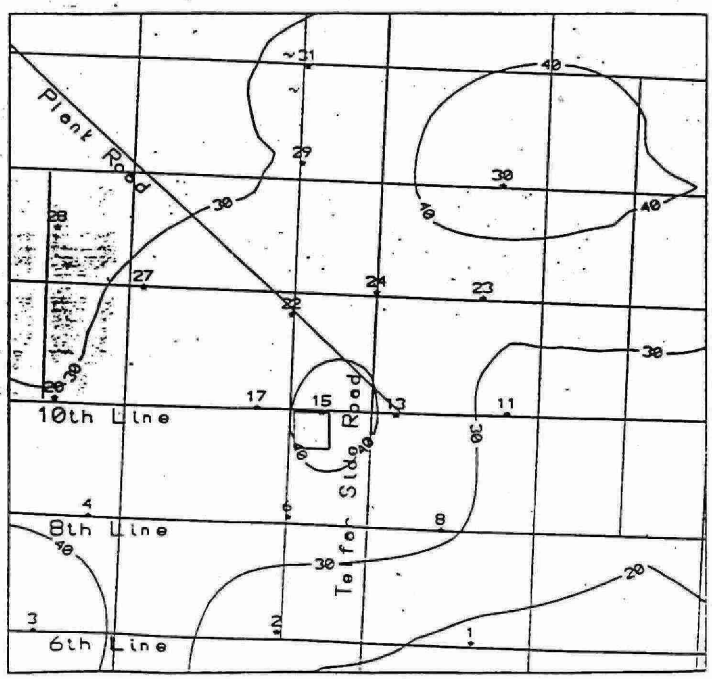
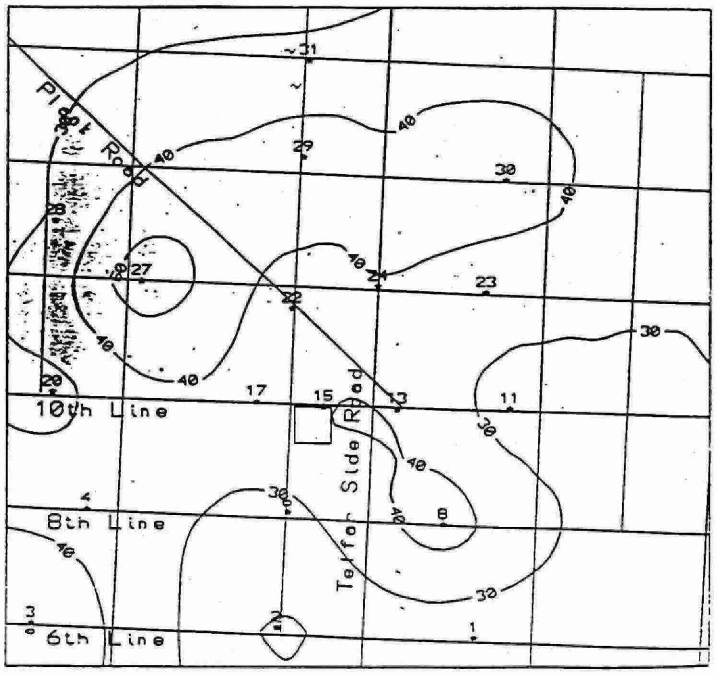


FIGURE 30 94 V ZN



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations

FIGURE 31 93 S CU

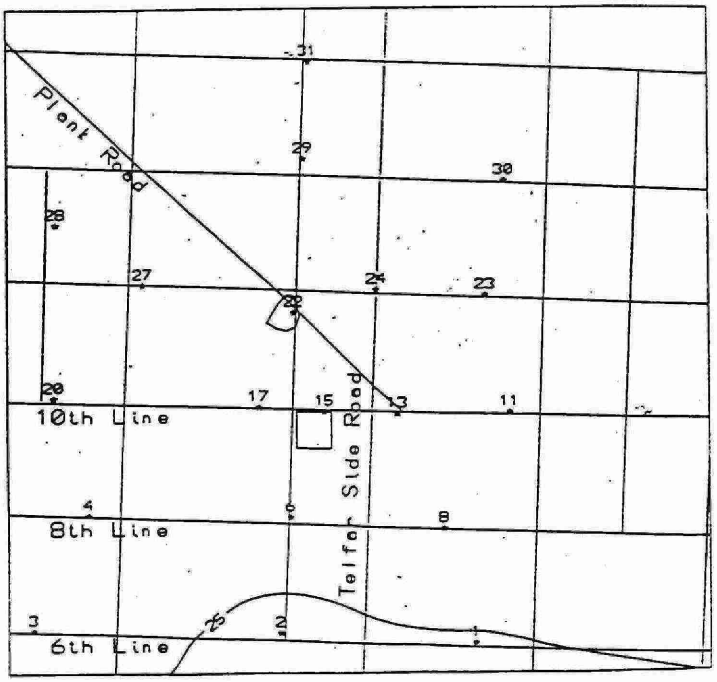


FIGURE 32 93 S NI

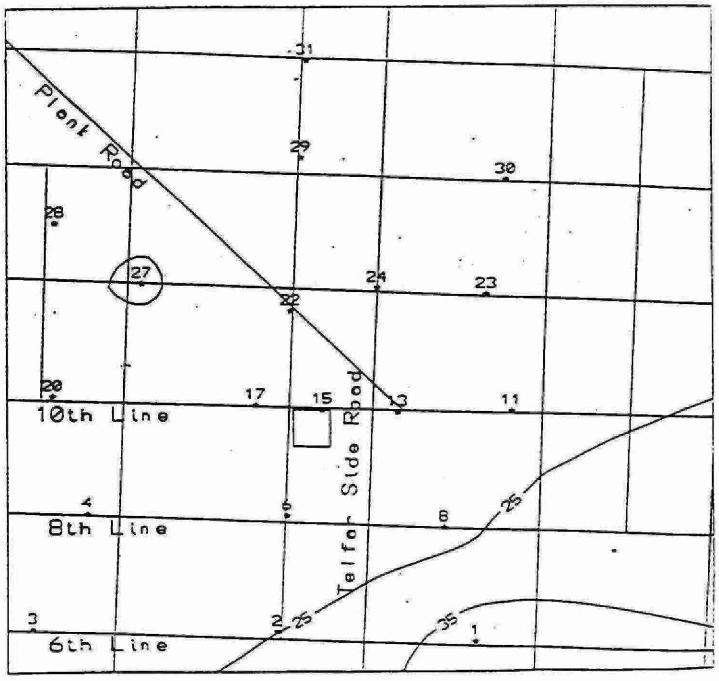


FIGURE 33 93 S PB

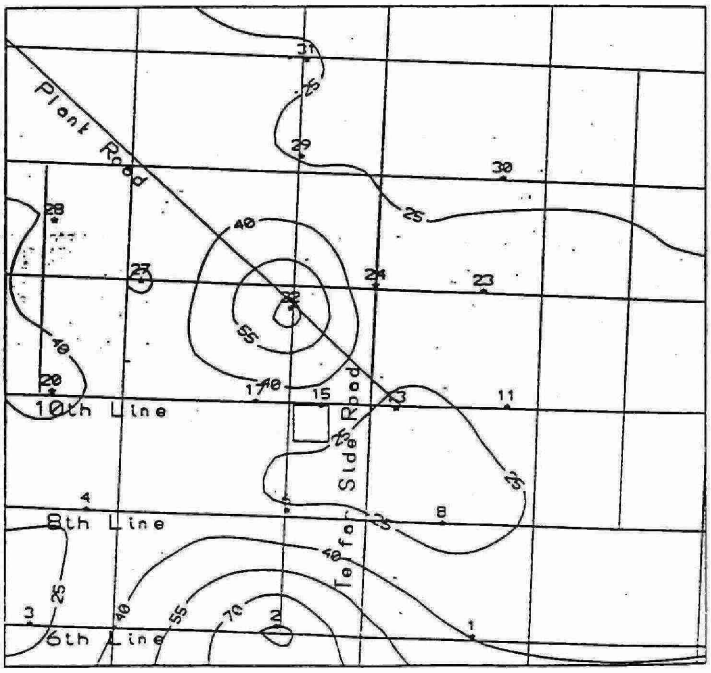
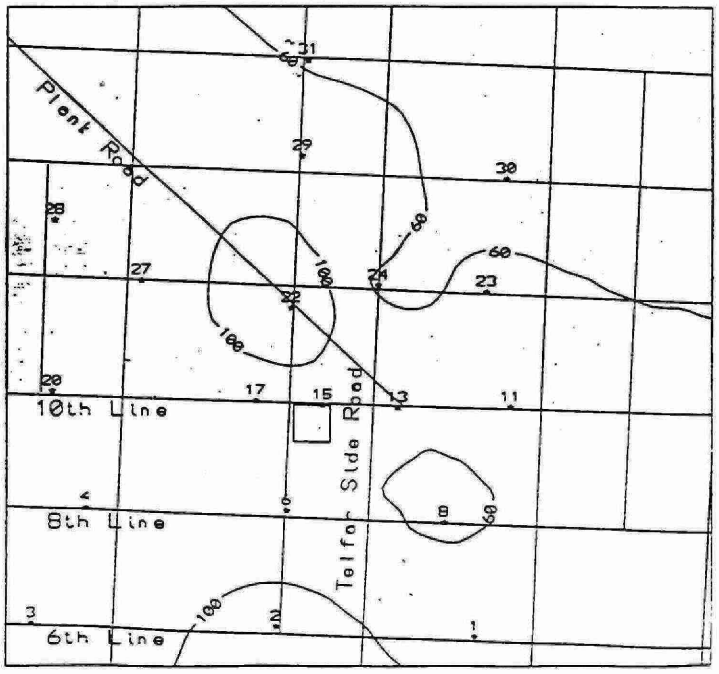


FIGURE 34 93 S ZN



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations

FIGURE 35 93 S FE

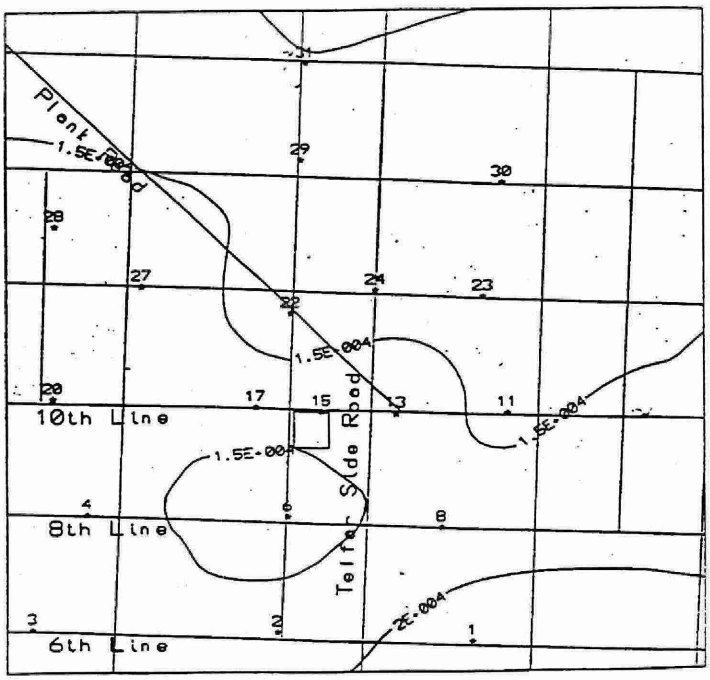


FIGURE 36 93 S MN

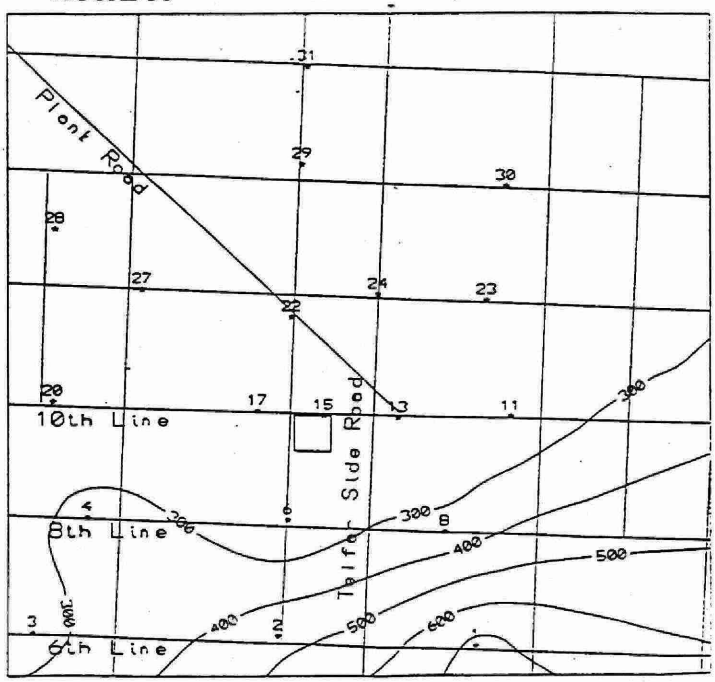


FIGURE 37 93 S AL

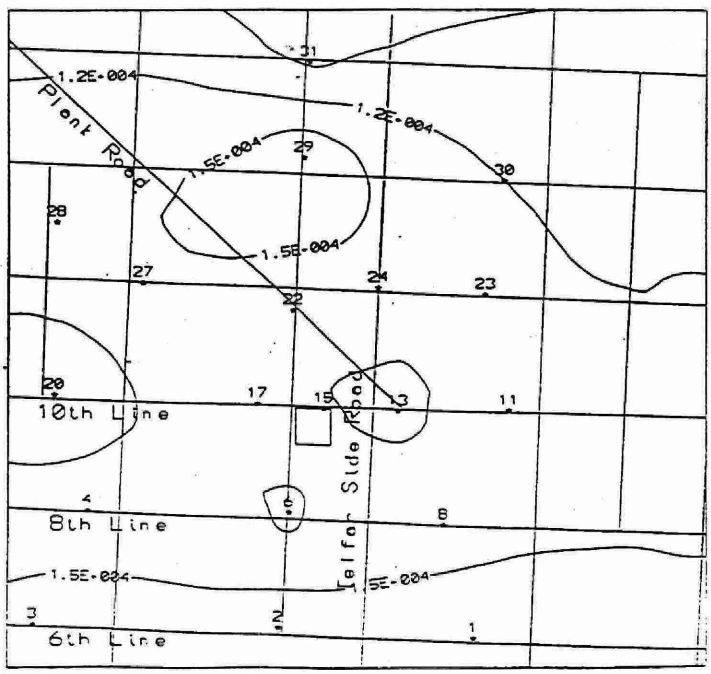
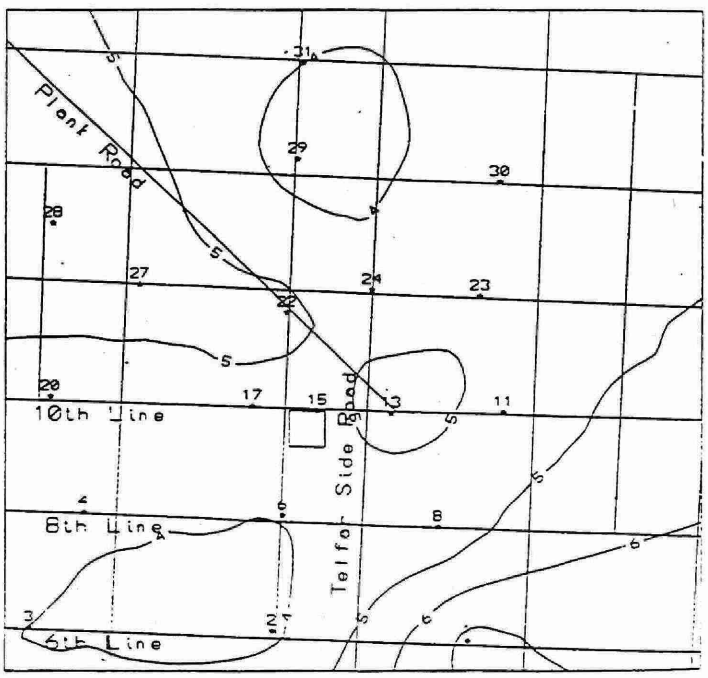


FIGURE 38 93 S AS



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations

FIGURE 39 93 S SA

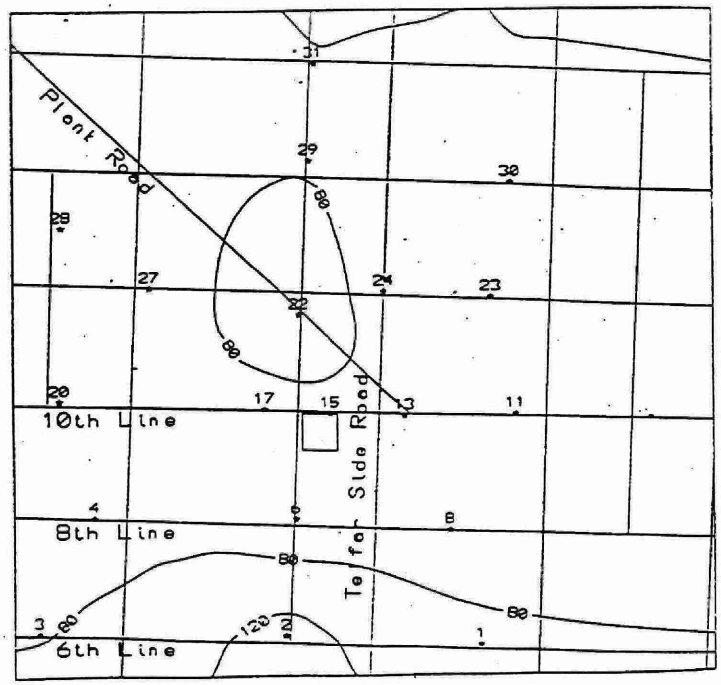


FIGURE 40 93 S CD

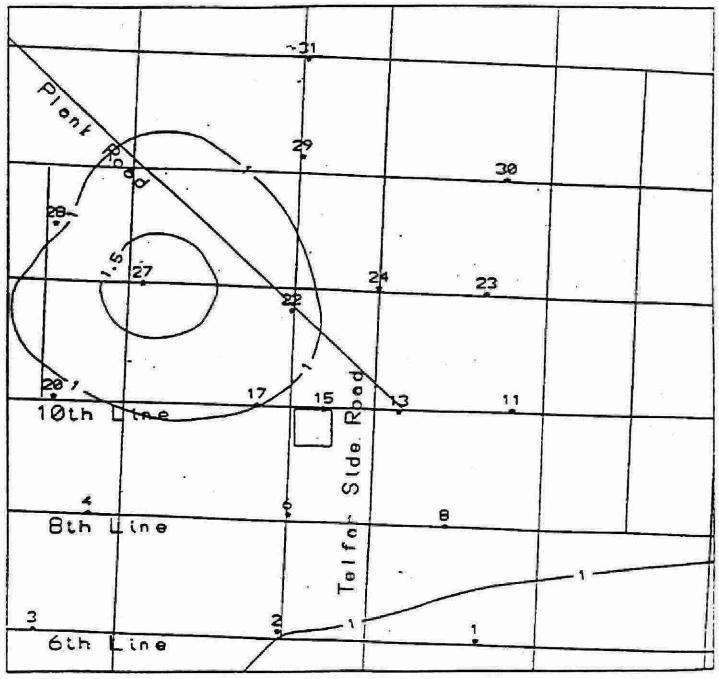


FIGURE 41 93 S CL

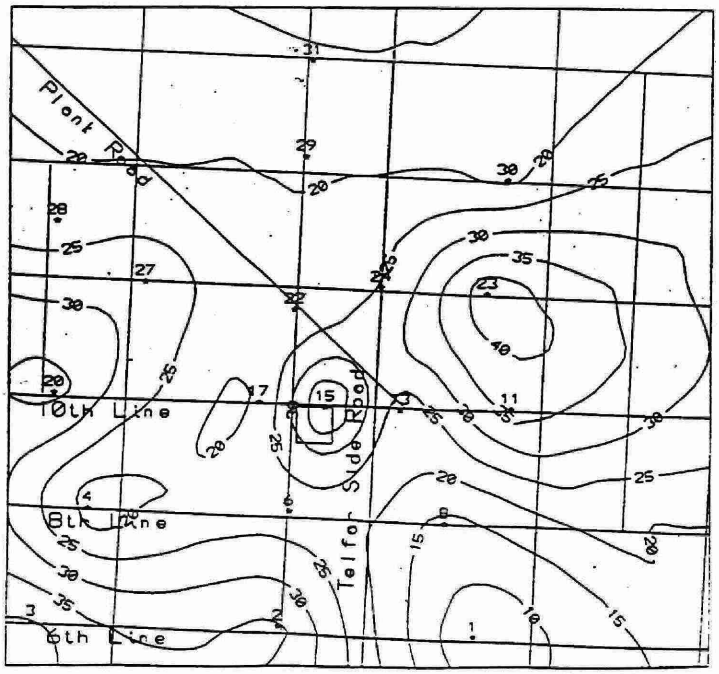
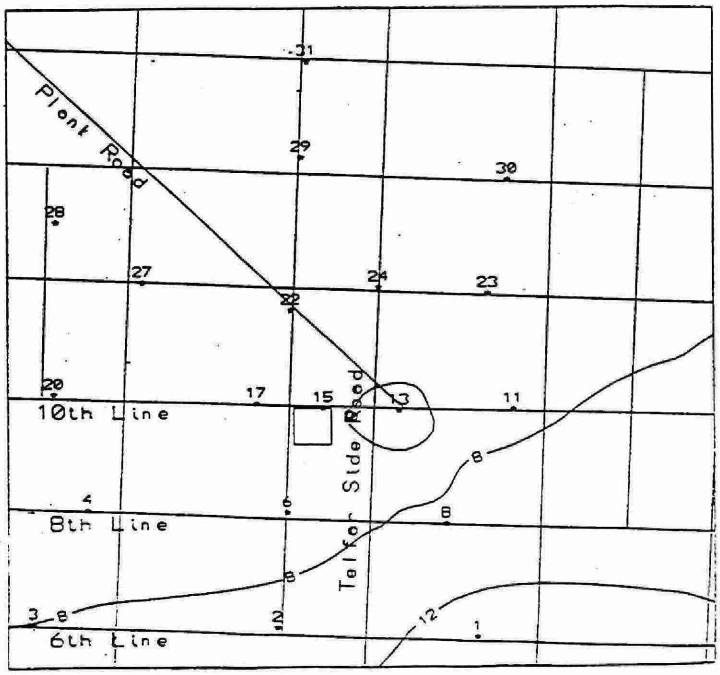


FIGURE 42 93 S CO



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations

FIGURE 43 93 S CR

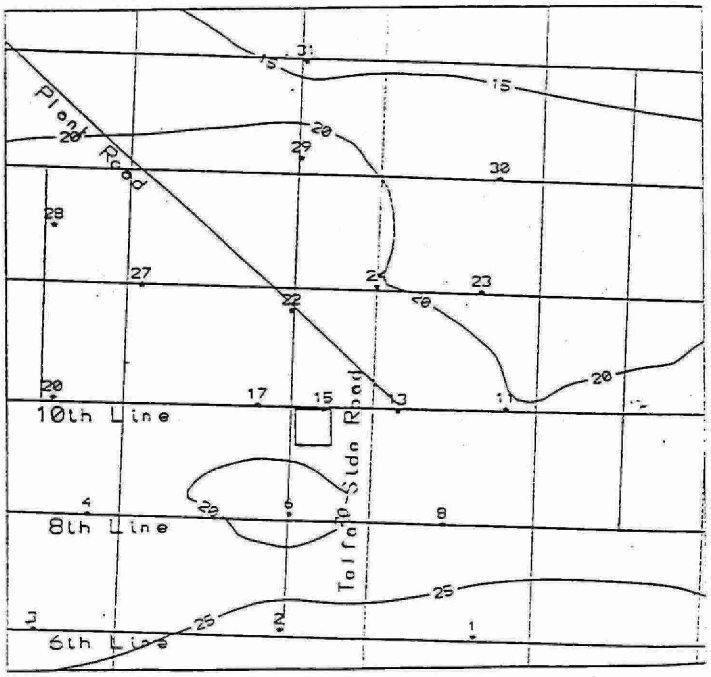


FIGURE 44 93 S HG

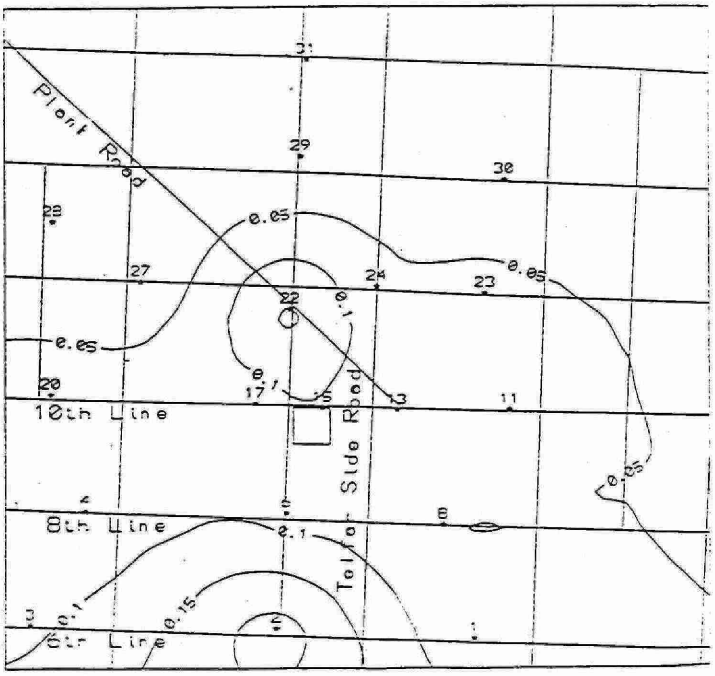


FIGURE 45 93 S MG

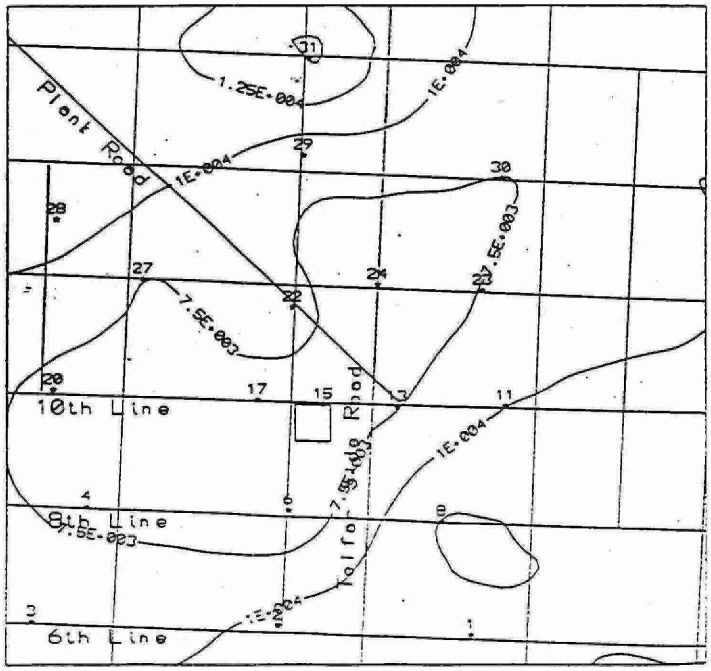
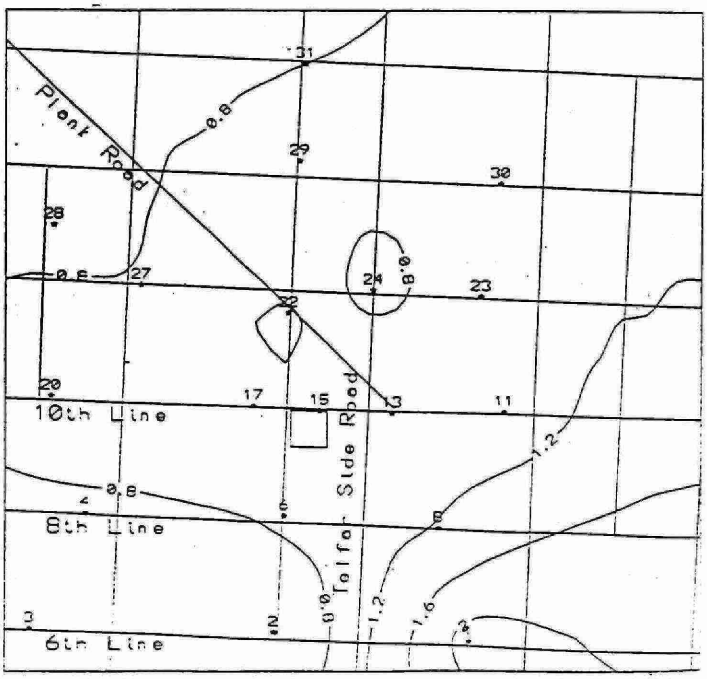


FIGURE 46 93 S MO



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations

FIGURE 47 93 S NA

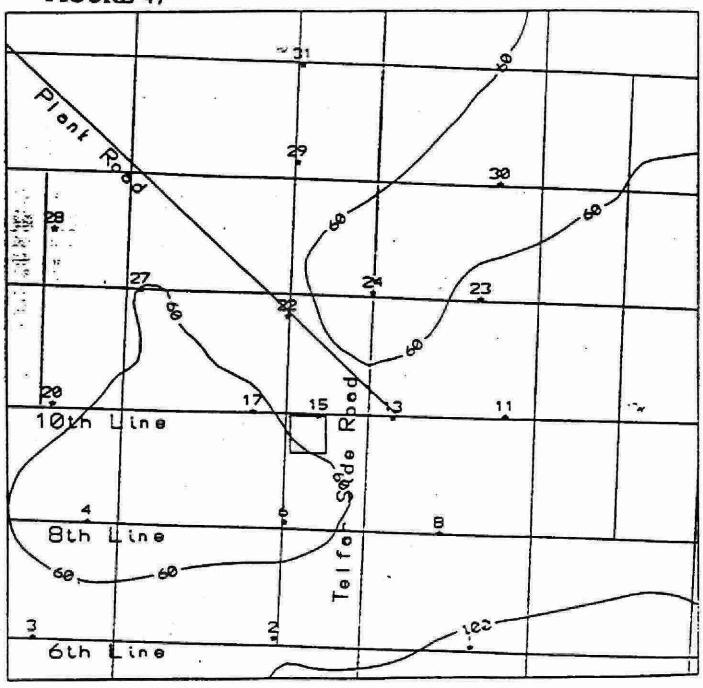


FIGURE 48 93 S SB

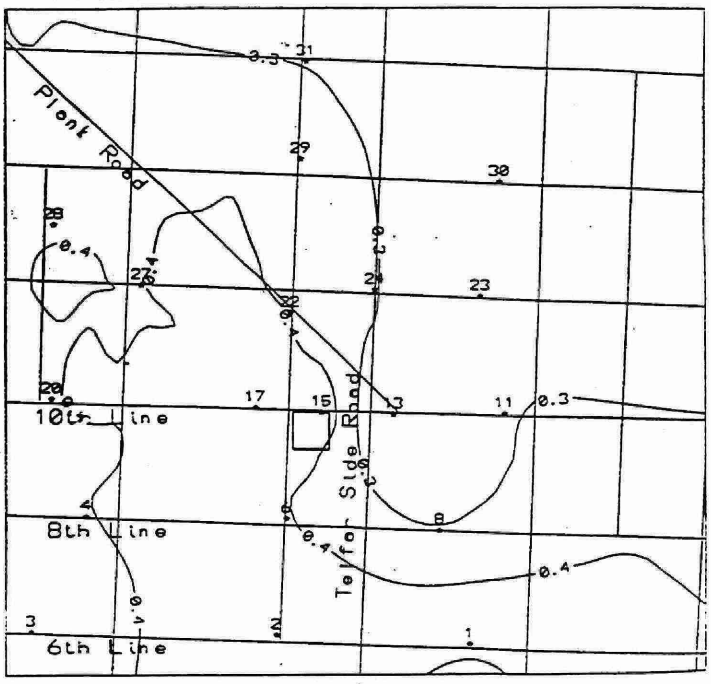


FIGURE 49 93 S SE

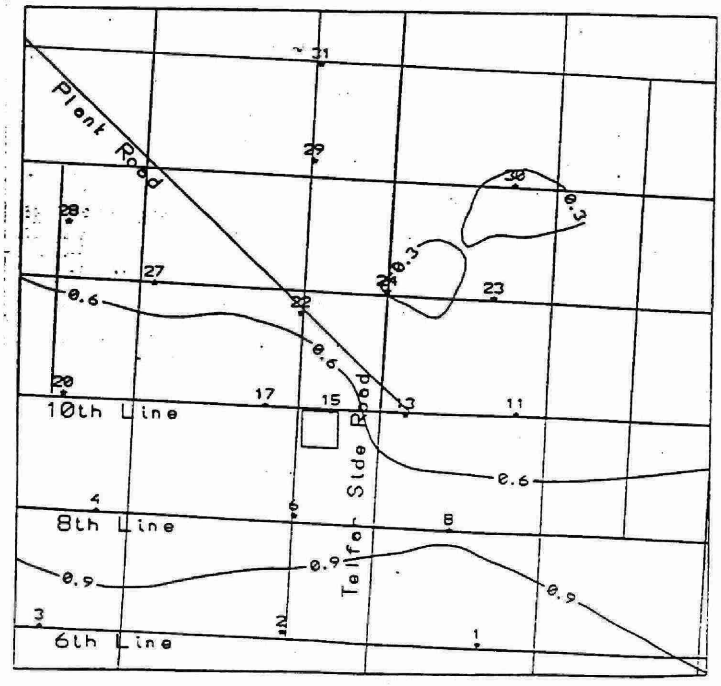
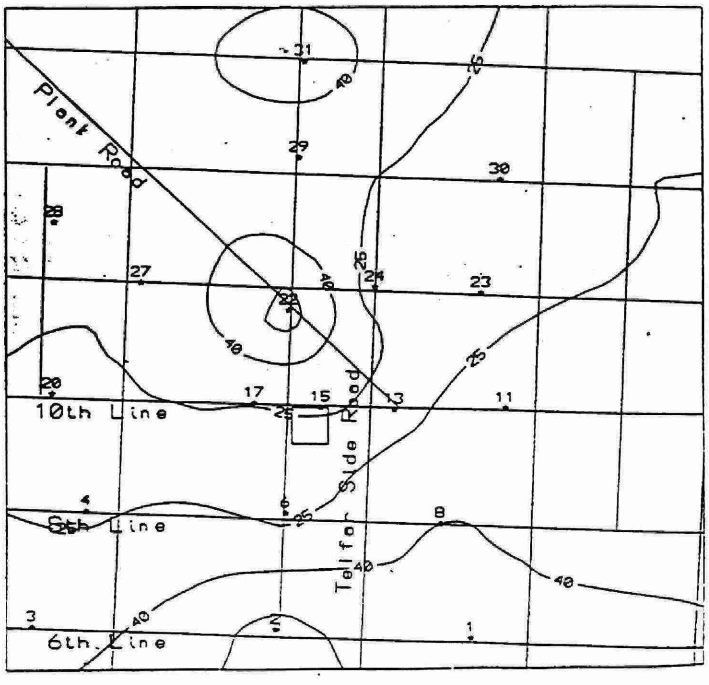
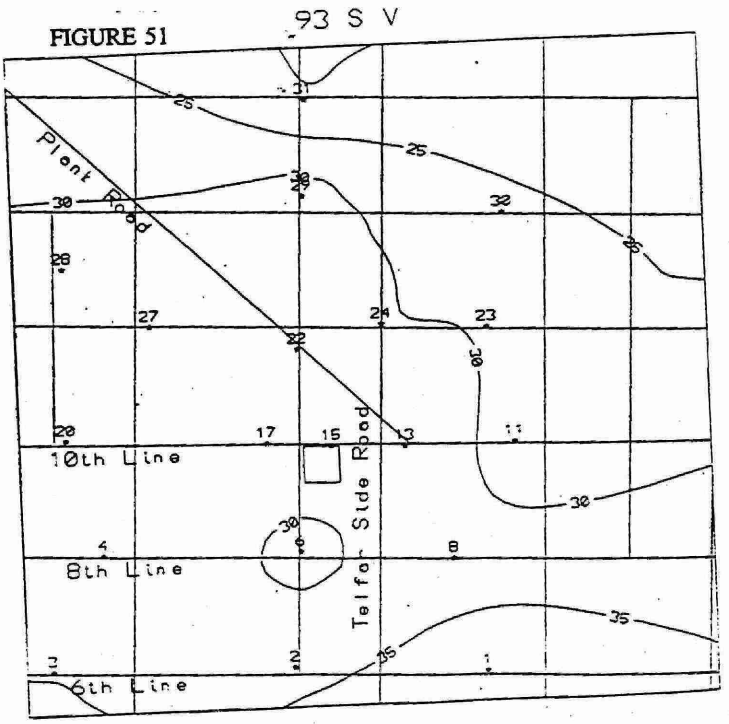


FIGURE 50 93 S SR



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations

FIGURE 51



94 V Hg = 1994 Vegetation Mercury Concentrations
93 S Hg = 1993 Soil Mercury Concentrations